TRAINING FOR WORK IN THE COMPUTER AGE:
HOW WORKERS WHO USE COMPUTERS
GET THEIR TRAINING

IES
421

by

Harold Goldstein
and
Bryna Shore Fraser

ORIGINAL

June 1985 RR-85-09

RESEARCH REPORT SERIES
NATIONAL COMMISSION
FOR EMPLOYMENT POLICY
1522 K STREET, N.W.
WASHINGTON, D.C. 20005

Researchers undertaking studies for the National Commission for Employment Policy are encouraged to freely express their own opinions. The views and opinions expressed herein are solely those of the authors, and do not necessarily reflect the official opinions or position of the National Commission for Employment Policy.

FOREWORD

This study, funded by the National Commission for Employment Policy, is directed at learning what training is required by people who work with computers or computer-based equipment. Its purpose is to lay a factual basis for consideration of policy in education and training that would best aid in adapting the American workforce to the requirements of this new and pervasive technology.

The study involved interviews with employers, workers, trade and professional associations, and unions in many different industries, as well as officials of computer manufacturing companies and schools, to find out what workers in each occupation do with computers and how they learn to do it. The National Institute for Work and Learning is indebted to those interviewed for their interest and cooperation. We also wish to acknowledge the considerable assistance received from members of the staff of the Bureau of Labor Statistics working on occupational outlook research and the collection of occupational employment statistics. Carol Jusenius Romero, Stephen E. Baldwin, and Sara B. Toye of the National Commission for Employment Policy provided encouragement and direction to us throughout the course of this study, and we are grateful to them for their support.

The manuscript was typed--on computer-based word processing equipment, of course--by Veronica Jenkins and Judith Goldstein.

BLANK PAGE

PREFACE

Trying to anticipate the effects of the computer revolution on human employment has become a national preoccupation. Thousands of men and women currently employed in production jobs glance nervously back over their shoulders at the predicted advance of robots. Larger numbers in service occupations wonder whether new equipment about to be installed will make demands on them they can't meet or will make them redundant. Commentators debate a predicted demise of virtually all "middle-class" jobs.

A related uneasiness pervades the educational and training establishments. Curriculum developers at both secondary and college levels try to assess the changing career needs of students entering an "information age." At what levels should what degrees of computer acquaintance and competence be developed? Should students be offered a variety of computer learning opportunities or should new components be added to mandatory courses?

Balanced reaction to this situation challenges individual and societal capacities. The change is coming rapidly but with no way to measure its pace or plot its course. Magnifying with an apocalyptic title what others consider semi-delirious concern, Christopher Evans sets the 1990's as the decade for the Micro Millenium, when computers will have taken over work so completely that the riddle of the human future will have to be left to them. The sale last year of over two million commercial or professional type computers, requiring this many additional employees to learn new competencies, offers firmer substance for more restrained projections. Fear of the unknown freezes out level-headed calculation of the new opportunities that are the converse side of the prospect.

Goldstein and Fraser introduce into this context some data that seem at first to conflict with these other prognoses but emerge on closer attention as stabilizing facts. Looking at some 140 occupations in which there is evidence of computer usage, they find that the degree and extent of change in the skill requirements of the vast majority of jobs is much less than has been generally thought.

The report in no way minimizes the extent to which "the computer's widespread use is changing the demand for labor, the content of work, the location of the workplace, and the quality of working life, as well as the training required for jobs." Analyzing particular occupations and professions -- scientists, engineers, programmers, systems analysts, computer testing technicians and repairmen -- the reporters remark that "the adequacy of education and training in these fields is central to maintaining world leadership in the face of active competition."

The authors' main conclusion, nevertheless, is that although computer use is widespread and growing rapidly, relatively few workers need [at least so far] extensive education or training in computer-related skills. Although about one in eight workers is found to be using computers in one form or another, most of these are using available software; the necessary skills require only a few hours to a few weeks of training, followed by a period of learning in the course of work. "Less than one percent of all workers require long periods of training."

Putting the Goldstein/Fraser findings beside those that others have emphasized warrants several suggestions regarding the development of perspective in this confused area. One is simply that full account must be given to the critical differences between the kinds of computer skills that are required of, for example, an engineer or a scientist, a programmer, a secretary, and a supermarket clerk pulling coded packages across sensitized scanners. Each of them has the same weight in overall statistics for computer users. Yet the computer-skill components of their occupations have almost nothing in common. Lumping them together gives a distorted picture.

Making the distinctions that are required here lessens both the scare elements and in some respects the immediate promise of the "revolution." Young people leaving school without knowing how to use a computer are worrying unduly about their careers being permanently stunted. On the other hand, students and displaced assembly-line workers alike will be properly warned against relying for their futures on learning computer programming — which Goldstein and Fraser find is needed by no more than two percent of all workers.

The magnitude of the totals of employees using computers tends to conceal the fact that for the large percentage of these workers the computer component is a small element in the job. Training for this component alone won't be enough.

Most important of all is clear recognition that analyzing the computer skill components of jobs is only one factor in determining education's responsibilities in this area. Expressly abstaining from trying "to evaluate what should be taught about computers as a contribution to general education," the authors of this report recognize the importance of a "broad understanding of the computer and how it is used [among] a much wider segment of the population as consumers ... or simply as citizens."

The fact that less than one percent of all present jobs requires extensive computer training leaves entirely open the possibility that well-designed courses to develop computer learning afford superior opportunity for meeting education's underlying and overriding obligation, which is to teach every student how to think. Courses in computer programming may well have value to some students who won't ever engage in this function, at least in connection with their employment. A course in Computers and Society seems an ideal response to Thorstein Veblen's warning that the free society's ultimate testing will be whether it can withstand the strains and stresses between what he called scientific invention and the human purpose.

Education's critical responsibility is to keep putting the development of the whole person in the first place, instead of someplace else on down the line — below, for example, training for jobs. Determining what computer skills jobs currently require doesn't answer the question of what kinds of computer learning will contribute not only to individuals' careers but also to their effectiveness as citizens and to their making the highest and best use of the life experience.

Goldstein and Fraser have provided an invaluable illumination of the effects so far of computers on jobs. Their report prompts renewed concentration on the complex and crucial equation of education and work — and people.

Willard Wirtz
May, 1985

TABLE OF CONTENTS

PAGE

Foreword i

Preface iii

Executive Summary 1

I. Introduction 4

- A. Purpose and design of the study 4
- B. The computer explosion and some of its consequences 6
  - 1. Rapid emergence of the computer 6
  - 2. Illustration of computer use in two industries 8
  - 3. Some consequences of the spread of computers 11
- C. Training and education issues 14
- D. Types of computers and related terminology 15

II. Training in occupations involved with computers: summary of findings 17

- A. The occupations involved with computers 17
- B. Training required 18
- C. Training activity 22
  - 1. Formal training programs, enrollments, and completions 23
  - 2. Financing of computer training 33

III. Policy issues 34

- A. Role of schools in computer education 34
- B. Retraining displaced workers 36
- C. Training programs of vendors 36
- D. The choices for an individual 37
- E. Looking ahead 38

IV. Training required in individual occupations 40

List of occupations for which training is described 40

Statistical Appendix 88

References 103

About the Authors 109

EXECUTIVE SUMMARY

Computers have rapidly achieved widespread use, permeating many industries and affecting many kinds of workers. The growing use of computers has created concern about job placement, skill obsolescence, the adequacy of education, and additional barriers for minorities to overcome in gaining work skills. Schools are asking how they can best equip students to work and live in an age of computers. Questions arise about the roles of employers, schools, and government in helping people to get the training needed.

To provide answers to some of these questions, this study undertook to find out what training is required for work with computers or computer-controlled equipment.

The study identified as many as possible of the occupations in which workers use computers. Interviews were conducted with employers, workers, trade and professional associations, unions, computer manufacturers, and schools to learn what workers do with computers and how they learn to do it.

The main conclusion is that, although computer use is widespread and growing rapidly, relatively few workers need extensive education or training in computer-related skills; most learn their skills in brief on-the-job training. Young workers need not fear being frozen out of the job market because they have not learned about computers.

The rapid growth of computer use and its penetration into all sectors of the economy is illustrated by these key figures:

- Seven and a half million commercial or professional type computers (as distinct from home models) were in use at the end of 1984. In 1984 alone, over two million were sold.

- About 140 occupations were identified in which some workers use computers. They comprise about 30 percent of the work force, but less than half the workers in these occupations use computers at present - a total of about one worker in eight.

The significant fact is that the number of workers using computers is growing rapidly. Sale of over two million computers in 1984 (some of which replaced older equipment) means that more than two million additional workers had to learn to use computers in a single year - a number more than half as large as the combined annual high school and college graduating classes.

Extensive computer-related training is needed by relatively few workers. The one out of eight workers using computers fall into three major groups with respect to training requirements:

I. About five percent of computer users (less than one percent of all workers) require long periods of training. They include the engineers and scientists who design computers, teachers of computer science, computer programmers, systems analysts, and repairers. These occupations are growing rapidly, but by 1995 they will still be no more than about one percent of the workforce. The fact that this critical group of workers is relatively small does not diminish the immense importance of the quality of their training to the future of computer technology.

The rest of the workers involved with computers use them as tools in their jobs, mostly with already-prepared computer programs.

II. Some engineers, scientists, technicians, accountants, and other professional and technical workers cannot always get software that will do their work and have to be able to write their own programs. These workers amount to roughly five to ten percent of computer users and about one percent of all workers. They can learn programming by a single college course, or other brief training, or by reading a manual. Whatever method they follow, the real learning takes place on the job as they gain experience. Few become as expert as professional programmers.

III. All the rest of computer users, including most members of the occupations listed under group II, operate computers with available software for such purposes as data or word processing, information storage/retrieval, or industrial process control. They can learn the necessary skills by brief training, from a few hours to a few weeks, followed by a period of learning in the course of work.

For nearly all workers in groups II and III, computer skills are a small addition to the total job skills in each occupation. For most employed workers, the training is paid for by employers and provided by the companies' own training or supervisory staffs, vendors of computing equipment, professional associations, unions, or schools. Some learn their entire craft skills in longer training programs in which a small part of the time is spent in learning the computer aspects of the job. For workers not yet employed, schools can effectively teach some computer skills if students have ample opportunities for practice.

As computer use spreads, it is likely that the largest increase in the number of workers requiring computer skills will be in the third category requiring minimal, quickly-learned skills. In an intensely competitive market, software producers vie with each other to provide "user-friendly" programs for many applications, reducing the need for users to write their own programs.

The preponderance of employer-provided training for the third group of occupations reflects both the need to train currently-employed workers quickly in response to the rapid introduction of computers and the fact that fast-changing technology and threatened obsolescence of existing equipment favor on-the-job training. As emphasis shifts to training of new workers, however, the schools are likely to have a somewhat greater role, especially in training in word processing, electronics, and programming and in incorporating computer aspects into the general training programs for various occupations.

Two points that came up frequently in the interviews bear on the shaping of schools' computer training curricula: the computer skills in any occupation are only a small part of the total work skills; and ample opportunity for practice is essential in learning computer operating and programming skills.

While this report is not designed to evaluate what kind of general education about computers ("computer literacy") should be given to the whole school population, the finding that only a small fraction of all workers have to learn programming suggests that the general curriculum need not include this skill for the purpose of preparing youth for work.

Programs to retrain workers displaced from their jobs are most likely to be effective if they teach the total bodies of skills needed in the occupations for which they are being trained, rather than computer skills alone, since computer skills are generally a small part of total craft knowledge.

Students and young workers who want to improve their employability by taking courses in computer skills in schools should get computer-related training as part of the total training for occupations they are interested in, rather than as a separate skill, and should select courses in which ample time is allocated for practice.

How can we be sure that the information on which this study is based, reflecting the current situation, is appropriate for planning education and training policies designed to meet the future requirements of jobs in a rapidly changing technology? First, with one worker in eight already using computers, major patterns of computer use, skill requirements, and training methods have become well established. Second, to reflect the future as much as possible, we included occupations in which any workers, however few, now use computers, on the assumption that once their use has been introduced in an occupation it is likely to spread; and in the interviews on each occupation, we tried to describe the most advanced applications of computers rather than the most typical. While new applications not now foreseen will be developed, experience has shown that after any innovation is actually introduced, it takes time for use to become widespread. We can be reasonably confident of the validity of the findings as a guide to education and training policy for at least a few years. To pick up emerging changes, a study like this should be repeated every five years or so.

It may seem paradoxical that such widespread use of a technology many people associate with abstruse mathematics and electronics can be attained with relatively little special education and training. Yet this conclusion emerges clearly from the many interviews conducted. To understand this, one needs to recall that such innovations as automobiles, television, plastics, telephones, and electricity have become nearly universal while requiring relatively few highly-trained workers, mostly engineers and crafts workers in their manufacture, installation, or repair. The computer is becoming prevalent mainly because it has been designed, and constantly and ingeniously improved, to make it easy to use.

The long-term effects of the computer on work, after several more decades, cannot now be foreseen, any more than the revolutionary social and economic effects of the automobile could have been predicted at the beginning of this century. The progress of this innovation requires continued watching.

I. INTRODUCTION

A. Purpose and Design of the Study

Few technological innovations have entered the economy so rapidly, permeated so many industries, and affected so many different kinds of workers as has the computer. Few have raised so many questions or awakened so many concerns--about job displacement, robots in the workplace, skill obsolescence, and additional barriers for minorities to overcome in gaining work skills. Schools are asking how they can best equip students to work and live in an age of computers. Questions arise about the roles of industry, schools, and government in helping people to get the training needed.

To provide answers to some of these questions, this study undertook to find out what training is required for work with computers or computer-controlled equipment.

The approach was to identify the occupations whose work involved computers and to find out (1) what workers in these occupations do with the computer, and (2) what training they need to do it. We interviewed employers, supervisors, workers, professional societies, unions, schools, training institutions, and computer manufacturers--196 interviews in all. We sought at least two interviews on each occupation or the occupations in each industry; if a substantially inconsistent picture emerged additional interviews were conducted. Drafts of the descriptions for each occupation included in Chapter IV of this report were sent to those interviewed for review, and their suggestions led to many improvements.

About the training we asked: where it is given; how long the formal training, if any, takes; how much time after the period of formal training the worker requires to achieve proficiency; who pays for the training; and what this experience tells us about how to provide training in the future. We attempted, where applicable, to differentiate training for new entrants as distinct from present job-holders.

Our occupation-by-occupation approach is based on the view that occupations - groups of jobs requiring similar combinations of skills - provide the logical link between the complex and widely varying skill requirements of the economy and the training task of the educational system. The numbers employed in each occupation currently and in the future provide a rough guide to the proportion of students or trainees who will need to learn each kind of skill.

By conducting the investigation in terms of individual occupations - asking concretely what the worker does and what training is needed to do it - we may avoid the unfocused and overgeneralized thinking that characterizes much of the public discussion about education for the computer age. For example, the fact that writing programs is perceived to be one of the tasks required for using computers has led some of the originators of the "computer literacy" courses designed as general education for all children to include programming in the curriculum; 61 percent of the courses include programming (Ronald Anderson, 1982). Information on how many of the 105 million jobs in the United States actually require computer programming, while not the only consideration, could help in deciding whether it should be included as part of general education.

We have to consider whether information on present job requirements may fail to depict requirements in the future, which should guide the design of education and training programs. Computer use is growing and changing rapidly, and spreading to more occupations. How can we make sure that the results of this study, grounded in the facts about computer use in 1985, will be relevant to planning education and training for the future?

First of all, the use of computers in the American economy has already advanced far. As we note in a later chapter, one out of eight workers already uses computers; they are found in many different occupations and industries. We are not dealing with a technological innovation in its most preliminary and uncertain stages, but with one well on the way to maturity, with major patterns of computer use, skill requirements, and training methods already developed.

Second, we took two steps to help assure a focus on the future: (1) even if only some of the workers in an occupation were found to use computers, the occupation was included in the study on the basis that computer use is likely to spread; and (2) we tried to be sensitive to changes now under way and to describe the most advanced applications of computers in each field of work, rather than the most typical. This will help to assure the validity of the findings as a guide to training policy for at least a few years. Experience has shown that after any innovation has been introduced it takes at least a few years for its use to become widespread (James, 1984). To pick up emerging trends a study such as this should be repeated after about five years.

The possibility of asking in the interviews about future uses of computers or about new occupations that may emerge was rejected; the history of attempts to adjust institutions to technological change is littered with overblown forecasts and pie-in-the-sky visions, and we wanted to ground this study in reality.

We must also be aware of another possible limitation of our approach: current methods of training may be ad hoc responses to a rapidly growing need rather than the best methods. We found that in nearly all fields a variety of training methods have been followed. Current experience has stood the test of application in many different situations, with computers of various designs, in many occupations and industries. Nevertheless, in the future some other methods may be found superior; this is another reason why the study should be repeated.

It may be that some broad understanding of the computer and how it is used, sometimes called "computer literacy," is desirable for a much wider segment of the population as consumers of computer equipment or services, or simply as citizens in a world in which computers play an increasing role. (Brief summaries of the history of this concept are given in Hunter and Aiken, 1984, and Education TURNKEY Systems, Inc., 1985.) This study, however, is not intended to define computer literacy for these broad purposes or recommend how it should be taught or to whom; it is focused solely on training for work with computers. The use of computers in teaching school subjects, now being tried in many schools, is another issue this report is not intended to evaluate. Nevertheless, we should note that if either computer literacy education or computer-aided instruction becomes part of the general school curriculum what is learned may be relevant to later occupational preparation.

The remainder of the introduction describes the way in which computers and computer-controlled equipment are moving into the economy, pervading virtually every industry and affecting many occupations. It briefly reviews some of the consequences of this development on the demand for labor, the content of work, the location of jobs, and the quality of working life. The issues for education and training—the main subject of this study—are then posed. This is followed by a brief glossary of computer terminology.

The body of the report consists of: Chapter II, which summarizes the findings as to training required, the activities of schools and other training institutions, and financing of training; Chapter III, which discusses the policy issues; and Chapter IV which contains brief reports on each occupation, describing what the workers do with computers and how they learn the required skills. The report also includes an appendix on statistics about employment in computer-related occupations and the numbers of computers in use.

B. The Computer Explosion and Some of Its Consequences

1. Rapid Emergence of the Computer

In the history of industrial change few technologies have expanded as rapidly as the computer or penetrated so many sectors of the economy in so short a time. The sales of the kinds of computers used for business or professional purposes - i.e. from mainframes down to microcomputers (or "personal computers") - increased from 1960 to 1984 at an average annual rate of 33 percent, more than nine times the growth rate of the entire economy—a remarkable record of sustained growth in a single industry. Sales of the newest type of computer, the microcomputer or "personal computer," have doubled each year since 1975. Two million computers designed for business or professional applications were sold in 1984 and 7.5 million were in use at the end of that year (Appendix Table A-5); there were another 11 million designed for home use (Appendix Table A-6). In addition, industrial equipment with computer controls has proliferated: about 105,000 numerically-controlled machine tools were in use at the end of 1983, and about 15,000 industrial robots were in use by March 1985. (For references see Statistical Appendix.)

Unlike new technologies confined to a single industry, computer use has penetrated the economy widely. This is partly the result of its numerous applications. Computers are used for such widely differing purposes as calculation, processing of data, storage and retrieval of information, word processing, interactive teaching, and control of industrial processes. In many of the applications several of these functions are combined.

The very word "computer" recalls the fact that the earliest machines were designed to make complex calculations involving a great deal of work. Scientists, engineers, accountants, and actuaries are among the users of these applications.

Probably the most common use is by business firms in processing data for accounting or statistical uses. Firms in all industries use it for payrolls and other bookkeeping purposes. Banks and insurance companies use it for recordkeeping, utilities and department stores for billing, and organizations such as the Social Security system use it for keeping records on large numbers of individuals.

Computer storage and retrieval of information is used by libraries to compile their catalogues and keep records of borrowing, by legal and scientific organizations to store reference material and make it easy for researchers to find it, by publishers of lists and directories, and by reservation clerks to keep on top of available space and bookings.

Word processing has become a widely-used application since the introduction of the personal computer, or microcomputer, although it had earlier been done on terminals connected to larger computers. By making corrections or revisions easily and printing rapidly, word processing saves retyping and proofreading and speeds production of typed material. The computer with word-processing software is becoming a substitute for the typewriter, not only for typists and secretaries but for anyone whose work involves writing--scientists, journalists, writers, and other professional workers.

Interactive teaching is being used in some schools and also in industry. It involves not only drill and practice routines but also programs in which the student seated at a computer terminal is given information that is logically sequenced and then quizzed on what he or she has learned. This is an outgrowth of programmed learning, which preceded the use of computers.

The use of computers for industrial design and to control industrial equipment or processes is illustrated at some length in the following discussion because it is not as familiar as the uses described above.

a. Computer-aided Control of Processes

Computers are built into the control systems of electric generating plants, chemical plants and petroleum refineries, and electric transmission and distribution systems. They measure and report temperature, pressure, flow of materials or electric power and other events in the system, and they control the process automatically.

b. Computer-aided Design (CAD)

With a computer and a CAD program an engineer, architect, or drafter can produce a drawing on the computer screen with the necessary information and specifications so that it can be used by craftsmen or production workers to build or manufacture the object drawn. An engineer can simulate subjecting the object to stress and make engineering analyses to improve the design.

c. Computer-aided Manufacturing (CAM)

Microprocessors can be made a part of a machine in order to control its operation. There are a number of applications of this type:

- Robots. Robots manipulate tools or materials being worked on, to move them from place to place, position them for work, and do such work as welding, assembling, and spray painting. Some robots have sensors that tell the microprocessor the position of the object the robot is to work on. They are especially useful for jobs where heat, dampness, or industrial hazards (explosives, chemical fumes, etc.) are dangerous to workers.

- Numerically-controlled machine tools. In numerically-controlled (NC) machine tools a computer guides the cutting tools and controls the speed of the cut, the rate at which the metal is moved towards the tool, and the flow of cooling liquid.

- Graphic arts applications. Few industries have used computer-controlled and electronic sensing equipment more than the printing and graphic arts industries. Word processing is used for producing text, which is directly transformed into printing plates by phototypsetting equipment. Illustrations are transferred to printing plates photographically or by computer-controlled sensing equipment; color illustrations are separated into the primary colors by filters; the intensity of each color at each point on the illustration is sensed electronically and converted to digital information, at which point it can be manipulated or enhanced as desired by the plateworker using computer-controlled equipment. Text and illustrations are combined and arranged on the page by an operator using a pagination computer. In the press room computer-controlled presses automatically adjust the flow of ink and paper. Computer-controlled cutting and folding machines assemble the printed sheets for binding.

- Computer-aided grading and marking in the apparel industries. After a patternmaker determines the shape of each piece of cloth required to make a garment--back, front, sleeves, collar, etc.--a computer adjusts the pieces to the different sizes. The marker maker then arranges the patterns in miniature on the computer screen in a rectangular space representing the cloth to be cut, rearranging them to minimize waste in cutting. The computer draws the layout with a stylus on a large sheet of paper which is laid out over the cloth on the cutting table.

- Other industrial applications. A number of other applications are found in a few installations, but are not yet widely used. Flexible manufacturing systems control the flow of relatively small batches of similar products or parts through the various production steps each batch requires; the actual movement is by robots or conveyors. Automated materials handling systems are used in production or warehousing to move items through the succeeding stages of production or to bring items out of storage. The inspection and testing of products in the course of manufacture is computerized, thus speeding up the testing process. Electronic sensors coupled to computers are used to control production processes.

2. Illustration of Computer Use in Two Industries

The ways in which computers have been adapted to a variety of uses, pervading the operations of a large organization, may be illustrated by two examples in quite different industries—airlines and supermarkets.

a. Airlines

It is no accident that an airline finds many uses for computers, for time is of the essence in this business: flights are tightly scheduled; hundreds of reservations and arrangements must be made simultaneously for travelers who are on the telephone or standing before an airline counter; a pilot in flight needs a rapid flow of dozens of kinds of information on aircraft performance and location.

The following partial list of computer uses was reported by one major airline:

Reservation agents who answer telephone requests use computers to call up information on schedules, fares, and seat availability, and to make reservations. Ticketing agents at airports do all the above and write tickets with computers. Passenger service agents give seat assignments from a computer. Baggage service agents trace lost baggage with it. Crew scheduling is done from computers that tell who is already assigned to work at a particular time and who is available. Computers are used to calculate the total weight of passengers, freight, and fuel on each flight and the center of gravity of the aircraft. Air freight agents use computers to look up the cost of shipping and to trace freight. The personnel office uses them to keep an up-to-date record of the training each employee has had to find qualified employees for assignments. Maintenance staff keeps a service record on each airplane and an inventory of spare parts, and orders parts with a computer.

Pilots, while on the ground, use a keyboard to put their flight plans into the flight management computer on the newest models of aircraft. This calls up from the computer's memory the airports, ground navigation aids, and radio stations en route, and the radio frequencies on which flight information is broadcast. Also recorded on the screen automatically is input from instruments measuring speed, altitude, temperature, fuel consumption, and other performance characteristics of the plane. If pilots, while flying, want to simulate a change in flight plan to see if it will help, they can put this into the computer with a keyboard and get a reading, while the computer continues to record information on the actual conditions.

Aircraft mechanics use computers to diagnose engine problems and for diagnostic checks of all electronic components; computerized "test boxes" are actually built into the newest aircraft.

The above listing includes only uniquely airline uses; each airline has many other office, management, and professional workers who use computers, as do similar workers in other industries, for word processing, financial and office records, calculation, or data storage and retrieval.

b. Supermarkets

Though the use of computers in supermarkets and grocery stores may seem less pervasive to the casual observer than in the airline industry, in fact a growing number of operations in the store and behind the scenes are becoming computerized. The main impetus for this is the labor and money savings which result from increased speed and availability of reports on a number of store-operation areas that previously could not be traced and controlled so accurately.

Among the supermarket services and functions that can be computerized are: direct store delivery; meat management; produce management; pharmacy; employee time and attendance; labor scheduling; energy management; payroll; accounts payable and receivable; scanning support; shelf labels; check authorization; sales/labor reporting; inventory management; and shelf allocation.

The most obvious of these (to the shopper) is the use of point-of-sale cash registers or scanners at the check-out stands. As of November 1984, a third of the 30,000 supermarkets in the United States had installed scanners, computerized machines that "read" the price of an item by scanning the universal product code printed on the label. Less obvious uses of the computer include automated direct store delivery. While 65 percent of an average store's 9,000 products come from a central distribution center, the remaining 35 percent arrive directly from hundreds of vendors who drop off fresh produce, baked goods, dairy products, and other items with a short shelf life. These deliveries may be made as often as every day, and each item has to be checked in and out manually by a clerk. With automated delivery, instead of using paper and pencil, the clerk inventories incoming goods using a laser gun attached to a portable data entry terminal. This information is then plugged into the computer, and immediate printouts are obtained for matching with the vendors' invoices.

The hand-held, programmable data terminal can also be used for a variety of other applications including produce and meat inventory, causal data collection (factors that may have influenced the sale of an item: was there an in-aisle display? a window sign?), shelf-stock audit, and deli/bakery master recipe control (keeping track of changing ingredient costs).

Computers are also used in the meat department to help the butcher get a better yield from cutting. Instead of using a knife in trial and error, the butcher uses the computer to simulate the cutting that will produce the optimum yield. The butcher can also use the computer to retrieve data on different meat packers to determine which one will help offer the best prices. The computer can also be used for price and record maintenance and report generation for electronic scale systems, such as those used for weighing meat and produce. In addition, the computer assists in perishables management, monitoring the perishable goods in the store to reduce loss.

The computer can print out shelf tags, including the appropriate bar code symbol, as prices are changed and can determine quickly and easily shelf-space allocation (what product gets how much space), using complex mathematical formulas. Computers have been used for several years to help with energy management systems and to control heating and cooling costs through usage analysis. The computer also keeps track of all aspects of employee time and attendance, payroll, and labor scheduling, as well as performing scanning data analysis, analyzing the data from the scanners to improve cost controls and enhance store merchandising.

A growing number of grocery stores are using their computers to become part of the Uniform Communications System, which allows for computer-to-computer reordering of groceries. This system eliminates paper purchases and the back-and-forth flow of mail and telephone confirmations. More supermarkets are tying into electronic banking systems, offering their customers the use of automatic teller machines, which grocers see as an opportunity to improve their cash flow.

Some of the larger grocery chains are also offering computerized *pharmacies*. The computer can keep updated records of a customer's prescriptions, provide prescription records for insurance and tax purposes, advise the customer of problems with existing allergies, and provide immediate warning of potential drug interactions from one or more prescriptions. The computer can also update drug prices, maintain accounts receivable and third-party billing, and assist in pharmacy management, profit, and inventory control.

Outside the store itself, the computer is used for *transportation and distribution center management*, *vehicle maintenance reporting*, and *warehousing operations*. Some grocers are using computerized storage and retrieval systems in their warehouses for more efficient space management. One large grocery chain, for example, has a software program working off a central computer which knows the "address" of each in-house product and where there are vacancies. Each time a "robo-carrier" guides incoming pallets into the warehouse, computerized cranes lift the pallets into available slots.

As more and more software is developed for use in large and small grocery stores—and this software is proliferating rapidly—it is likely that even more areas of this industry will be introducing computerized operations, affecting the majority of jobs from cashiers to store managers.

This brief review of the use of computers in two industries involving quite diverse technologies and ways of doing business illustrates how computers have been imaginatively adapted to many different tasks, and suggests that they are likely to be even more widespread in the future.

3. Some Consequences of the Spread of Computers

The computer's widespread use is changing the demand for labor, the content of work, the location of the workplace, and the quality of working life, as well as the training required for jobs. While this report focuses on the latter, some of these other changes help to set a context for the way in which training is done. They are well summarized in a recent study by Werneke (1984).

a. Changing Demand for Labor

Like other technological innovations, the computer is likely to reduce demand for some types of workers while increasing employment opportunities for others. Jobs have been lost in typesetting and composition work in the printing trades, processing of large-scale statistical surveys, and drafting, and there is some evidence that the clerical occupations, in which female workers predominate and in which they are so heavily concentrated, will be affected (Austin and Drake, 1985; Werneke, 1984). This leads to concern about the need for women to get broader training that will enable them to enter a wider range of occupations.

On the other hand, the computer has created 1.2 million new jobs (as of 1982) in the entirely computer-related occupations of programmers, systems analysts, computer operating personnel, data entry keyers, and repair technicians (Appendix Table A-3). Large numbers of new jobs have also been created for engineers, scientists, technicians, salesworkers, and production workers in computer and software manufacturing—an industry with over 400,000 employees exclusive of the entirely computer-related occupations listed above. Needless to say, the newly-created jobs require different skills than the jobs lost.

b. Changing Content of Work

While the computer's effect on some jobs is to reduce the level of skill and complexity of the work and make it more routine, the work content of other occupations is enhanced as the computer takes on the boring and repetitive tasks and leaves the worker free to use broader skills and to concentrate on more interesting and creative aspects of the work.

The "deskilling" effect of the computer may be illustrated by what sometimes happens when word processing is introduced into an office: secretaries may be segregated in a typing pool, losing their varied secretarial duties and personal contacts and becoming something closer to production workers. Another example is in the maintenance work in telephone central offices: the computer-controlled switching system diagnoses its own malfunctions, reducing the trouble-shooting skills needed by the maintenance technicians.

On the other hand, the machinist or machine tool operator who learns programming for numerically-controlled machine tools can say goodbye to repetitive production work in a noisy shop full of sharp metal shavings and slippery with cooling fluids, and instead move into a quiet office where he or she programs each new machining operation on a keyboard.

Each occupation is affected differently: the same word processor that may put the secretary into a typing pool frees the professional worker who uses it to make any number of improvements or revisions in a manuscript without concern about a retyping burden or the necessity of laboriously proofreading each new version.

For most workers using computers as a tool, the basic professional or craft skills are generally still required; a new skill in computer operation or programming is added. By making complex computation more feasible, computers enable workers in some occupations to accomplish work they were not easily able to do before. For example, scientists, engineers, social scientists, and accountants are now able to make quantitative analyses of problems or simulations that were not possible without the computer. This has called for additional mathematical or statistical skills and has added to the educational requirements in those occupations, quite aside from strictly computer operating or programming skills. This effect is found mainly in professional and some managerial occupations.

c. Location of Work

Computers hooked up with telecommunications make it possible to decentralize workplaces and even enable some people to work at home. Branch offices have been established in suburban areas, reducing rent costs, enabling some workers to avoid long commuting trips, and companies to tap new labor supply, but taking jobs away from the inner cities where minority workers live. Banks move clerical activities to states where banking legislation is more advantageous.

Working at home is now possible for people in many professional and clerical occupations. For disabled persons or women with family responsibilities this could make employment more feasible. One of the drawbacks, the loss of opportunities for professional or personal contact with fellow workers, may be offset by the employment possibility offered to people who could otherwise not work at all.

d. Quality of Working Life

A curious and paradoxical mix of reactions to this new phenomenon can be observed. On the one hand, many take to the computer with enthusiasm, buy it, and learn how to use it and program it to do new tasks. Teen-aged hackers hunch over it, probing its possibilities. Technically trained workers are likely to be interested in computers and eager to learn the new techniques. Young upwardly mobile professionals make a point of being computer-friendly.

> The majority of drafters look forward to CAD training. As a rule...technical people are fascinated by computer graphics and can't wait to get their hands on a system. Some look at the training as an opportunity to find out more about computers and learn a new skill. Some see it as a professional step-up and a way to avoid technical obsolescence. Others are excited by the possibility that the drudgery will go out of their work. And there are those who feel it's just plain fun. (Schreiber, 1984)

On the other hand, many people fear and distrust the computer or what is done with it. As noted above, anxiety about job loss is realistic for some occupations. For others, the distrust is more a compound of conservatism, fear of the unknown, and concern about the limitations of machines. Older members of many a profession distrust both computers and their younger colleagues who use them so blithely. (They may get some satisfaction from the remark of an eminent mathematician to the authors of this report that older mathematicians share these feelings.) A generation gap has developed in many occupations, with the computer marking the boundary.

Some individuals have an aversion to the paraphernalia of keyboards and terminals. Despite its potential for reducing the burden of library research for lawyers, many members of this profession prefer to leave the use of the equipment to paralegals, secretaries, or law librarians. The very quality that attracts scientists, engineers, and other quantitatively-oriented professions to the computer seems to repel many people in other fields.

Another and more serious reaction to computerization is "terminal burnout," a condition reported by some companies, in which people sitting before computer terminals all day long develop such symptoms as eye problems, backache, neck pains, numbness in feet and hands, and headaches, with an accompanying decline in accuracy and productivity and an increase in absenteeism. This reaction may be partly psychosomatic, a response to the mystique of the computer. It may also be a reaction to stress, induced in part by work monotony, difficulty in reading video screens, or fear of the use of the computer's capability to monitor the quantity of work output. There may, finally, be real physical hazards in the electronic equipment (Austin and Drake, 1985).

C. Training and Education Issues

The economic and social effects of the computer, touched on above, must be kept in mind as we turn to the issues in the field of education and training that are the principal focus of this study.

The size of the training task is formidable. If over two million computers enter the business world in a single year, as happened in 1984 (Table A-5 in the Appendix), very few of them replacements for obsolete equipment, then more than two million workers have to be trained to use them. We may gain some perspective on this figure by noting that it is half the combined size of the high school and college graduating classes.

One of the questions is what proportion of the workforce will have to learn the new skills. The Office of Technology Assessment, in a November 1982 report, said, "Learning how to use [computers] is a basic skill that will be required for many and perhaps most jobs." On the other hand, the view is expressed that as equipment becomes more sophisticated the knowledge required to use it declines and only minimum introductory instruction is required (Rumberger and Levin, 1984). These scenarios are not in fact mutually exclusive, but the implications drawn from them tend to go in opposite directions: some people see a need for teaching about computers to all children in the schools, and there are advocates for doing this at each of the levels of the educational system, not excluding kindergarten; while others minimize the problem and recommend doing most of the training by ad hoc methods on the job, except for the education of advanced scientists, engineers, and a few other occupations.

The spectre of displacement from jobs raises different issues: should workers who are about to lose their jobs due to the introduction of computers or computer-controlled equipment be given training for new jobs involving computer skills? If so, what kinds of training are needed, what institutions should provide this training, and who should pay for it?

Looking to the future, beyond the training of people now in the labor market, what should be the relative roles of the educational system and each of its levels and components and of employers or computer manufacturers in teaching about computers? Should the costs of computer education and training be borne by the public in the budgets of the public educational system or by the employing institutions (industry, government, etc.) through on-the-job training? Should it be made a part of the cost of the equipment if the training is supplied by equipment manufacturers? Should schools attempt to develop a broad "computer literacy," and what should this include—i.e., should it include knowledge of what computers can do and understanding of their role in society and the problems and issues associated with their use, or should it also include hands-on skills in computer operation or programming?

For computer manufacturers there is a choice between giving the training without charge but including its cost in the price of the equipment (which may be unfair to customers who make little use of the training) or charging for the training and even setting up training divisions of the company as profit centers.

For individuals there are also choices: should families respond to the advertising pressures to buy a home computer to help children with their school grades? Should students seek computer training in school, and what kind of training, or should they depend on employers to provide training?

These issues of training gain additional urgency from the need to maintain the world supremacy that the United States has attained in the computer industry. Computers are not only a major export item at a time when the balance of trade is going so heavily against this country, but they have a strategic and military importance far beyond the dollar value of their export earnings. In this knowledge-based industry our edge is our skilled scientific and technical workforce and the special knowledge, experience, and creativity of scientists, engineers, programmers, systems analysts, and computer testing technicians (U.S. Department of Commerce, Office of Assistant Secretary for Trade Development, 1984). The adequacy of education and training in these fields is central to maintaining world leadership in the face of active competition.

It is to shed some light on these issues that this study attempts to determine in concrete terms specifically what education or training is required by each of the categories of workers who use computers or work on them.

D. Types of Computers and Related Terminology

This new technology has accumulated an impressive quantity of jargon, and a brief glossary will help the reader to understand the subsequent sections of this report. (This section is based, in part, on Tidball and Shelesnyak, 1981.) "Hardware" is computerese for equipment, and "software" is the term for instructions or programs stored in the computer's memory or on disks or tape.

a. Hardware

The two principal kinds of computer are those designed to stand by themselves and those designed as the controlling part of the machinery for an industrial process. Computers that stand by themselves ("stand-alone") come in sizes ranging from mainframe computers that can store and rapidly process large amounts of information through minicomputers to microcomputers, the "personal computers" that have become so popular. They may be classified by memory capability—the number of "words" or "bytes" they can store. No classification system is universally accepted, but the following will illustrate the range:

Verbal description	Number of bytes of memory
Microcomputer	4,000 to 256,000
Minicomputer	32,000 to 256,000
Mainframe computers	
Midicomputer	64,000 to 1,200,000
Maxicomputer	more than 500,000

The swift pace of change in this technology is illustrated by the fact that in 1981 microcomputers were available with storage capacity of not more than 64,000 bytes.

The computer itself consists of a central processing unit that does the work and various peripheral devices, such as a terminal (a keyboard plus a display device like a television screen), a mass storage unit, a printer, and a modem to communicate with other computers through the telephone system.

The controlling part of industrial machines or instruments may be either digital computers (working with numbers) or analog computers, in which the inputs are continuous variables such as temperature, pressure, or speed, and the outputs are similarly continuous--either graphs on a screen or the movement of controls on industrial machinery.

b. Software

There are two main categories of software: operating systems and application programs. Operating systems are internal to the computers; they instruct the computer how to do its basic work, using the only language the computer understands, that is, one that indicates whether an electrical element is off or on, which may be expressed as "0" or "1". A binary number system capable of expressing any number can be developed from combinations of 0 and 1, just as a decimal number system can express any number by combinations of 10 digits from 0 to 9.

Programs to tell the computer what to do can be written in three ways: (1) in binary; (2) in an "assembler language," which uses abbreviations and symbols that can be translated into binary by the computer; or (3) in a "high-level language" closer to English, such as FORTRAN, COBOL, BASIC, FOCAL, or APL, made intelligible to the computer by mechanical translation into assembler language. Typically, only computer professionals use an assembler language; most people in other occupations who do programming use one of the high-level languages.

An application program is a set of instructions which permit a computer to accomplish a specific task. It is not built into the computer, as the operating system is, but is recorded on a tape or disk which is given to the computer temporarily, for each specific task. An application program may be either generic, like a word-processing program that can be purchased, or one written for a specific task, like an airline's reservation system.

Writing application programs in a high-level language is a relatively simple task, and many users learn to do this or to make minor modifications in existing application programs to meet their specific requirements. If a task is voluminous and is repeated many times, it pays to have the program written by an experienced programmer who may use an assembler language rather than a high-level language in order to achieve more efficiency.

II. TRAINING IN OCCUPATIONS INVOLVED WITH COMPUTERS:

SUMMARY OF FINDINGS

A. The Occupations Involved with Computers

At the outset of this study a list of about 100 occupations tentatively identified as being involved with computers was drawn up. In the course of interviews it was found that some of those in the list did not use computers, but other occupations turned up that did. This brought the final list to about 140 occupations. A few additional occupations were identified in which computers were used in the same way as those for which descriptions were written for Chapter IV, and with apparently similar training, but it was not possible within time limitations to include them all in Chapter IV. It is likely that there are additional computer-using occupations that were not identified. Nevertheless, on the basis of the interviews, reading the literature in the field, and discussions with people engaged in research on computers or in occupations research, the authors believe this report covers the great bulk of computer use in the United States at the present time and accurately represents the training requirements.

In the 140 occupations, 30 million workers were employed in 1982--about 30 percent of all civilian workers employed in that year (See Appendix Table A-1). In many of the 140 occupations, however, not all the workers are currently involved with computers; in some, including such large occupations as teachers, cashiers, and lawyers, relatively few now use computers. On the basis of the interviews it may be estimated that roughly 12 million workers used computers as of 1982 - one in eight workers.

A figure of this magnitude gains some support from data on the number of computers in use. The number of business-type (as distinct from home model) computers in use at the end of 1984 was about 7-1/2 million; a total of 7.6 million had moved into domestic consumption since statistics were first collected (Appendix Table A-5), but some of the earlier models are no longer in use. Of the total, 6.9 million were microcomputers or "personal computers" which probably average not much more than one user per computer. The rest, 682,000, were larger computers to which multiple terminals can be connected so that each computer may be used by more than one worker. There are no data on the total number of terminals in use, but in 1982 U.S. manufacturers produced about 12 terminals for every large computer produced and in 1983 about seven for every large computer (Appendix Table A-7). If these two years' production ratios are a clue to the ratios of terminals to computers in use, we may estimate from the number of mainframe and minicomputers in use that between five and eight million terminals were in use at the end of 1984. Adding these to the 6.9 million microcomputers in use, we get between 12 and 15 million facilities for computer users in 1984. Not all computers or terminals are used by workers; for example, those in schools are used by students. On the other hand, many microcomputers or terminals are used by more than a single worker.

Employment of programmers, systems analysts, and computer operators grew at average rates in the neighborhood of 10 percent annually over the past decade, comparable to the rate of growth of the number of mainframe and minicomputers in use (Appendix Tables A-2 and A-5). The number of microcomputers, which are typically used by members of other occupations, grew at a much faster pace. The numbers of computer repairers and data entry keyers increased more slowly than employment in the three occupations referred to above.

B. Training Required

The findings of this study as to the computer-related training required are summarized here, on the basis of the detailed discussion of each occupation in Chapter IV. To generalize about the diverse situations in these occupations is to do many of them an injustice, as will be apparent when one reads the individual discussions. Each occupation has its own history and traditions, work content, industrial attachments, union or professional organizations, and traditional modes of education or training, to which the new skill requirements imposed by the computer are added. With this caveat in mind, one can see a few broad patterns of training emerging from this review.

In attempting to identify the computer-related education and training requirements for 140 occupations, one of the difficulties we found was that training methods vary considerably among members of a single occupation, and there is usually no standard method. For example, we discovered that some law schools are training all their students in the use of computers through specific computer education courses, while other schools expect their students to pick up the skills needed on their own, with a wide range of variations between these two extremes. As another example, computer programmers may have taken college courses in computer science departments, or short courses provided by computer manufacturers, or may have learned by self-study and experience.

Due to the lack of hard data on the proportion of workers in an occupation trained by each method, it is difficult to determine definitively what type of training is currently most prevalent or what time frames are most common for achieving proficiency in use of the computer. Our aim is to provide a description of the range of computer training opportunities, indicate relative prevalence where there is some evidence, and, wherever possible, make note of any training trends that seem to be developing within an occupation.

The occupations may be divided into three main groups according to the amount of computer-related training they need.

Group I: Occupations Requiring Extensive Computer Training

The first group of occupations, those requiring extensive training, includes: the engineers and scientists, who design the equipment; computer systems programmers, who design the internal operating programs; applications programmers, who design the applications software; computer systems analysts; computer repairers; programmers of numerically-controlled machine tools; and college teachers of computer science. Each requires quite different training, but in each case the training takes a period of years and usually involves a combination of formal schooling and experience. Altogether this group amounted to 600,000 workers in 1982, about 0.6 percent of all workers in the United States and roughly five percent of computer users. These are rapidly growing occupations but even by 1995 they are projected by the Bureau of Labor Statistics to amount to only one percent of all workers. (These figures are based on Appendix Table A-1 and the Bureau of Labor Statistics report from which it is derived. Engineers, scientists, and mathematicians in the office, computing, and accounting machines manufacturing industry totaled about 60,000 in 1983 according to an unpublished BLS occupational employment statistics survey.)

The finding that the number of workers requiring extensive computer training is relatively small should not be interpreted as meaning that the training of these critical workers is not important. Upon the adequacy and quality of their training depends the future of computer technology; this is particularly crucial at a time when the leadership of the United States in this field is being challenged.

The second and third groups of occupations use computers as tools in their work, and their computer skills are a minor addition to their professional or craft skills. The difference between them is that some workers in the second group, while usually operating computers with software already available, occasionally have to write programs, while workers in the third group use only available software and virtually never have to write programs. Not all the workers in each occupation in the second and third groups now use computers, and, while computer use is growing, some members of these occupations may never use computers.

Group II: Occupations in Which Some Workers May Require Training in Programming Computers as Well as Operating Computers

Workers in occupations in the second group can usually use software already available for calculating, word processing, modeling, or simulation but some of them may have to be able to write computer programs or modify existing programs. They are primarily workers in the scientific and technical occupations--engineers, natural and social scientists, persons in mathematical fields, and technicians associated with all of these--and a few other professional occupations such as architects, accountants, auditors, urban and regional planners, and medical records administrators. These occupations altogether amounted to about six percent of all workers in 1982. As noted above, only part of those in each occupation use computers, and only some of those who use computers have to be able to program. Those who actually program computers probably amount to no more than one percent of all workers and between five and ten percent of computer users.

Whether or not they have to write programs depends, of course, on whether software is already available to do their work. In an intensely competitive market, software producers vie with each other to provide "user-friendly" programs for any application for which there are enough potential customers to warrant the investment of high-skilled staff. For example, in a single recent issue of Amstat News (March 1985), published by the American Statistical Association, there were twenty advertisements for statistical software packages, each designed to perform a variety of standard statistical calculations. As another example, an inventory of agricultural software lists over 1,700 agricultural computer programs intended for use by farmers (Strain and Simmons, 1984). There are many programs for general business applications.

Not all applications offer a potential market large enough to induce a vendor to produce a program, but this does not necessarily mean that computer users have to be able to write their own programs. Many workers in occupations in group II are in colleges, universities, or other organizations in which expert programmers or computer science teachers are employed, and can call on one of them to write a new program for a special purpose. In some cases they may be able to borrow a program from a colleague, or get a graduate assistant, a student, or a technician to write one. Thus there are a variety of ways in which programs can be made available to meet a user's needs.

We do not want to imply that writing computer programs is so difficult or distasteful that users fall back on doing it themselves only as a last resort. Many rise to the intellectual challenge: if no program is available, they write one; if they think existing programs are awkward or inefficient or do not yield desirable by-products, they modify them or write better ones.

Rising to the intellectual challenge is so common a human response that there is probably no occupation in which a worker has not written a computer program related to the work of the occupation. For this reason, the distinction we have made between group II and group III, based on whether some members of the occupation have to be able to write programs, becomes a little hazy at the edges. Nevertheless it is worth retaining, because people interested in preparing to enter occupations in group II have to consider whether to get training in programming as part of their initial course work or to wait until the need to program actually arises and then take the training, while those interested in group III occupations are not confronted with this problem.

In assigning occupations between groups II and III, we have tried to focus on whether the work of the occupation actually requires programming for a significant proportion of the workers. Since there are no statistics on this, we relied on the impressions of those interviewed, and so, in some cases, had to make a judgment call.

A difficult case was the occupation of elementary and secondary school teachers. Relatively few teachers have had to learn programming. They include a few teachers of special education for the handicapped who have prepared instructional programs for their pupils; teachers assigned to teach "computer literacy" courses that include programming; vocational education teachers who teach programming; and elementary school teachers who teach programming in LOGO. Only a very small proportion of the 2-1/2 million elementary and secondary school teachers actually write programs or teach programming, and it is by no means certain that this number will increase significantly in the future. This profession serves as a good illustration of the tenuousness of the distinction between groups II and III, and its inclusion in group II dramatizes the point that the total employment in this group of occupations represents a substantial overstatement of the proportion of the work force who have to program computers.

The programming skills required by workers in group II are not nearly at the level of competence required of professional applications programmers, although some individuals in group II occupations may attain such skill levels. They write programs mostly in high-level languages rather than in the assembler languages used by professional programmers to attain more efficiency. Because programming is an extra skill for them, subordinate to their main professional interests, few of them have the motivation or the time to spend in developing this skill beyond what they need to get the work done.

Members of these occupations have learned programming in a variety of ways, including semester-long or longer courses in vocational or technical schools or in two-year or four-year colleges, one- to two-week courses (or a series of several such brief courses) given by employers or computer manufacturers, self-learning from manuals or computer-based instruction, or just learning from friends. Students in these fields at colleges frequently take one or more programming courses in the computer sciences department.

The variety of formal training methods may be illustrated by a few examples. One professor of mathematics recommended learning programming by taking a two-semester course involving three hours of classroom work each week and six hours a week in a laboratory with a microcomputer; this, he said, would not make a crack programmer but would help the student get started. Another said that most mathematicians (as distinct from undergraduate students) can learn by reading a manual and starting to program. The Graduate School of the U.S. Department of Agriculture in its 1984-85 Catalogue on Computer Sciences offers a comprehensive 11-week course to enable people without previous data-processing experience to qualify for positions as entry-level COBOL programmers. A major manufacturer of computer equipment offers a sequence of two five-day courses to enable an inexperienced person who has had college algebra to learn to write FORTRAN IV and FORTRAN 4X programs to solve a variety of theoretical problems (Hewlett-Packard Co., 1983). Short courses of this sort are offered by a number of computer manufacturers. The differences in class hours between five-day courses and semester-long courses are not as large as at first appears: a five-day course may mean 35 hours, and a one-semester course of three hours a week may mean about 45 hours. The real difference is that workers who take five-day courses begin to practice using the skill full-time immediately after training, while those in school but not working in a computer job have to find opportunities to practice.

Whatever the method of introductory training, one thing is essential: post-training experience in programming. This experience may be gained in the "laboratory" time in school courses, or in on-the-job learning. The learning is made easier if the student has someone to turn to for help—a friend, colleague, instructor, or supervisor.

Group III: Occupations That May Require Training In Operating Computers

Workers in the third group require only training in operating computers with software already available. These include most of the clerical, sales, and industrial process workers who use computers. They can learn their computer skills in anywhere from a few hours to a few weeks training - a testimony to the ingenuity with which computer manufacturers and software producers have attacked the problem of making the systems "user friendly." Much of this training is given on the job or in brief courses provided by the employer, manufacturers of equipment, unions, or schools.

In some cases the computer training is incorporated into a comprehensive training program for the occupation which takes considerably longer than a few weeks, but the time spent in learning the necessary computer skills is only a small part of the total. For example, the training of library technicians includes many aspects of library organization and procedures, including the classification systems for books and the methods of recordkeeping for books loaned out; the ways in which computers are used to locate books or control borrowing are an integral part of this learning, but the actual operation of the computer keyboard to call up information is a minimal skill in this broader context.

In addition to the brief formal training that is the most common method of learning, workers need an additional period of working with the computer on the job to perfect their skills. The time required to attain proficiency depends on many factors: the difficulty of the subject-matter with which the worker is dealing and his or her familiarity with it; the worker's familiarity, facility, and previous experience with computers; the amount of time the worker spends on using the computer (i.e., whether he or she works on it constantly, as a typist uses word processing, or only occasionally, as when a college professor uses a computer with word processing to write an article); and whether the work done involves all the operations with frequency, or whether some operations are required only infrequently and are therefore not encountered or learned until a long time after the worker begins using the computer. Because of these variables and because "proficiency" means different things in different situations, it is difficult to generalize on the number of weeks or months required to attain proficiency. In the descriptions of speed of learning in various occupations in Chapter IV of this report, the period ranges from a few weeks to six months or more.

People planning to enter these occupations can usefully study certain computer-related skills in schools, and thus enhance their employability. One of these is word processing, which is taught in secondary and postsecondary schools, and which is a useful skill for secretaries, typists, writers, journalists, and workers in a variety of professional, managerial, and sales occupations. Another is electronics and computer technology, which are taught in vocational and technical schools and in two-and four-year colleges and provide a good background for learning such occupations as telephone central office technician, computer operator, computer repairer, and avionics repair (one of the specialities of aircraft mechanics).

In summary, about 30 percent of all civilian workers are in occupations in which some workers use computers, but less than half of them--one in eight of all workers--now do so. Less than one percent of American workers (about five percent of computer users) are in occupations that need extensive specialized training about computers; roughly one percent of all workers (between five and ten percent of computer users) need to learn programming; and all the rest who use computers can learn the necessary skills in a few hours to a few weeks of training, most of which is given on the job or by manufacturers of the equipment. This widespread use of a new technology with relatively little special training reflects the success of the computer industry in making the equipment and software "user friendly".

C. Training Activity

As the study is primarily focused on computer-related training that is required in the occupations detailed in Chapter IV, it is important to examine the available statistics on training and education currently being given in computer skills through formal programs as well as the training provided by computer equipment manufacturers and employers.

1. Formal Training Programs, Enrollments, and Completions

The most recent compilation of training data is contained in the 1984 edition of Occupational Projections and Training Data published by the Bureau of Labor Statistics as a supplement to the 1984-85 Occupational Outlook Handbook.. Unless otherwise noted, the figures cited below are based on tables found in "Appendix C. Detailed Training Statistics" of that publication. We have included information only on the directly computer-related courses, such as programming, data processing, computer science, and computer maintenance. While courses in other fields in which computers are used (such as accounting and medical records technician) may also be teaching applications of computers, there are no statistics available that separate out computer-related training within the more general coursework offered in those occupations. Nor are there figures on the total numbers of students who enroll in one or two computer-related courses while completing a program in an occupation that is not directly computer-related. Particularly at the college and university level, figures are compiled by final award or degree earned.

Thus, it is clear that the figures contained here actually understate the number of people taking one or more computer-related courses during their formal education or training program, although there may be some overlap between categories of providers and the enrollment figures cited, due to varying data collection procedures used in different surveys by the National Center for Education Statistics (NCES). For example, the NCES category "public vocational education" includes public secondary, postsecondary, and adult vocational education programs while "noncollegiate postsecondary vocational education" includes 500 public schools (out of a total of 6,000 schools in this category), 70 percent of which are vocational/technical institutes. NCES notes that, as a result, there is likely to be some duplication in the enrollments and completions cited for these two categories.

a. Public Vocational Education

Computer-related vocational education programs are offered at three levels: secondary; postsecondary; and adult, which includes those already in the labor force who may wish to get retrained or want to upgrade their existing job skills. Training is usually provided in local elementary, secondary, and vocational school buildings as well as at community centers. Curricula generally focus on preparing trainees for specific occupations.

Many schools, especially vocational schools, are upgrading their equipment through donations from and partnerships with employers, and schools throughout the country are benefiting from contributions from computer manufacturers in particular. It is very likely, therefore, that computer training courses in a variety of fields will be increasingly available to regular full-time students as well as adult education participants. In 1978 (the latest year for which figures are available), participants in adult education indicated that they took 12,000 computer-related courses provided in elementary, junior, or high schools (NCES, 1979, Table 33).

The following table provides data on enrollments and completions in occupationally specific, computer-related public vocational education programs, offered during 1981-82 at or above grade 11 and designed to provide entry-level skills.

Table 1
Enrollments and Completions in Computer-Related
Public Vocational Education Programs
1981 - 1982

Title	Enrollments	Completions
Accounting and Computing Occupations *	420,837	113,418
Computer and Console Operators	57,441	14,267
Programmers	144,804	20,521
Other Business Data Processing	146,334	30,775
Totals:	769,416	178,981

* A major part of this category is accounting.

Source: Bureau of Labor Statistics, 1984, Table C-1, p. 97.

b. Noncollegiate Postsecondary Vocational Education

This category includes more than 6,000 private and public schools, the majority of which are proprietary schools, including a large number that specialize in business/commercial fields and offer a variety of computer-related courses and programs, such as: automation, bank teller, computer programming, data processing, electronic office machine technology, keypunch operator, secretarial, telecommunications, and word processing.

Noncollegiate postsecondary schools draw from two major groups: recent high school graduates interested in obtaining specialized vocational skills and adults seeking to update or improve existing skills or learn new ones. These schools do not grant degrees, offering primarily vocational and technical courses on a part-time and full-time basis. Programs last from brief one-to-three day seminars to two years. Classes for the longer programs usually are held five days a week, five hours a day, with tuition for a typical ten-month course averaging $2,000 at a private school and $600 at a public noncollegiate postsecondary school. Tuition for the shorter seminars, such as those providing an introduction to a specific software program, generally range from $100 to $400 per day at the private schools.

Noncollegiate postsecondary schools maintain a high degree of flexibility in admissions requirements and in courses offered and are generally responsive to local employment needs. In regard to the effectiveness of these schools in training students for actual jobs, however, evidence to date is mixed at best. Several studies have found that relatively few graduates of professional or technical-level training courses actually find jobs in those areas. This is particularly true for graduates of computer courses. In 1978, adult education participants indicated they took 38,000 computer-related courses at these schools (NCES, 1979, Table 33).

Many students at noncollegiate postsecondary schools do not complete a full training program in a particular field but are classified as having left with a "marketable job skill" if not with a certificate or other formal credential.

The following table shows total enrollments, completions, total who left with a marketable skill, and total still enrolled, by individual computer-related programs for noncollegiate postsecondary schools with occupational programs for 1980-81:

Table 2
Total Enrollments, Completions, Total Who Left with a Marketable Skill, and Total Still Enrolled by Individual Computer-Related Programs for Noncollegiate Postsecondary Schools, 1980 - 1981

Title	Total Enrollments	Completions	Left with Marketable Skill	Still Enrolled
Computer Operator	8,949	3,276	2,867	466
Keypunch Operator	13,670	7,899	882	2,039
Computer Programmer	40,246	22,329	2,539	8,009
Systems Analyst	206	99	10	61
Business Data Processing	45,880	21,580	3,147	12,496
Scientific Data Processing	64	64	0	0
Totals:	109,015	55,247	9,445	23,071

Source: Bureau of Labor Statistics, 1984, Table C-2, p. 100.

c. Community and Junior Colleges

These two-year colleges, numbering 1,296 in 1982-83, offer many computer-related courses and, because their tuition and fees are generally low (most are publicly supported) and their admissions policies quite liberal, they attract a large number of students from varying backgrounds. Average tuition costs in 1980-81 were $385 for public two-year colleges compared to $593 for public noncollegiate postsecondary schools and $915 for public 4-year universities (U.S. Bureau of Census, 1983 and NCES, 1984). In addition, community and junior colleges often work effectively with local businesses, providing employees with both generic and customized training designed to meet specific training needs. A growing number of employers, particularly those smaller businesses that do not have an in-house training capability of their own, are contracting with community colleges for both custom-designed and generic training programs. The majority of these programs involve a small number of employees and are of short duration, ranging from a one-hour seminar to a full-semester course, in such areas as office automation, management information systems, and data processing.

The 1978 adult education survey showed 166,000 computer-related courses taken at two-year colleges (NCES, 1979, Table 33). The following table lists only the number of associate degrees and other formal awards below the baccalaureate granted in a computer-related curriculum of at least one year during 1981-82:

Table 3
Associate Degrees and Other Formal Awards Below the Baccalaureate Granted in a Computer-Related Curriculum of at Least One Year, 1981 - 1982

Curriculum	Curricula of at least 2 but less than 4 years		Curricula of at least 1 but less than 2 years
	A.A. degrees	Other formal recognition	
Data Processing Technologies	11,086	465	1,476
Keypunch Operator & Other Input Preparation Technologies	65	20	855
Computer Programmer Technologies	8,167	355	1,504
Computer Operator & Peripheral Equipment Operation Technologies	374	114	726
Data Processing Equipment Maintenance Technologies	1,365	88	366
Other Data Processing Technologies	44	12	3
Totals:	21,101	1,054	4,930

Source: Bureau of Labor Statistics, 1984, Table C-5, p. 105.

d. Four-Year Colleges and Universities

Learning how to use computers is being facilitated for many college and university students by increasing ease of access. At many institutions of higher education, computer terminals or microcomputers are located in a central facility for students' use. More and more, students are buying their own personal computers, the use of which may be shared by friends or roommates. A recent survey by the American Council on Education found that over one-half of the freshmen entering state universities in 1983 had written at least one computer program, and about one-third had taken at least one computer-assisted course in high school (Education TURNKEY Systems, Inc., 1985).

In the 1984-85 academic year, there were nine colleges that required entering students to buy their own computers--seven of these institutions were engineering or technical schools. Many other schools strongly recommend, but do not require, purchase of a computer and have arranged with manufacturers for special discounts (The Chronicle of Higher Education, Feb. 20, 1985, p. 14). The most frequent use of computers on campuses is in word processing, but they are also used for calculating, simulation, and interactive learning with appropriate software.

Students may get help in using computers by taking courses in departments of computer science, which typically serve many more students than the number majoring in this field. Adult education participants in 1978 took 107,000 computer-related courses at four-year colleges and institutions (NCES, 1979, Table 33). The following figures include only bachelor's, master's, and doctor's degrees conferred in computer and information sciences in 1981-82.

Table 4
Bachelor's, Master's, and Doctor's Degrees Conferred in Computer and Information Sciences, 1981 - 1982

Major Field of Study	Bachelor's Degrees	Master's Degrees	Doctor's Degrees
Computer & Information Sciences, General	16,368	4,268	241
Information Sciences & Systems	2,433	541	10
Data Processing	960	28	0
Computer Programming	231	40	0
Systems Analysis	217	52	0
Other Computer & Information Sciences	58	6	0
Totals:	20,267	4,935	251

Source: Bureau of Labor Statistics, 1984, Table C-6, p. 108.

e. Armed Forces Training

The Armed Forces provide training in hundreds of specialized occupational skills. Characteristics of this training are as follows: over 33 percent of all Department of Defense (DOD) training is designed to provide initial orientation and indoctrination; over 55 percent is specialized skill training; and over 95 percent is designed to provide new skills to participants. DOD offers over 7,000 different courses, ranging in length from two to twenty-five weeks. Computer-related courses include training in computer programming, operation, repair, and maintenance. The majority of the skills learned in these courses are transferable to civilian occupations, and, historically, the military has long provided a way for young men and women to get technical training applicable to civilian jobs.

The following table shows the enlisted strength in Department of Defense computer-related occupational groups as of September 30, 1982:

Table 5
Enlisted Strength in Department of Defense Computer-Related Occupational Groups, September 30, 1982

Title and Description		Enlisted Strength*
ADP Computer Repairers		8,728
Data Processing -	includes computer operators, analysts, and programmers and electric accounting machine operators	16,906

* The number trained annually is of course less than the numbers shown above.

Source: Bureau of Labor Statistics, 1984, Table C-4, p. 103.

f. Employer-Provided Training

The clear impression from the interviews conducted in the course of this study is that employers constitute the largest single source of training in computer skills. This impression is confirmed by the 1978 Survey of Participation in Adult Education, which found that 236,000 computer-related courses were provided by business or industry, constituting 38 percent or the largest category of computer courses given (compared to 27 percent for two-year colleges and 17 percent for four-year colleges and universities, the next two largest categories).

The majority of workers who required training to work with computers acquired their skills through formal or informal on-the-job training. One common pattern for providing this training to experienced workers when new equipment was introduced was to give the employees brief formal group instruction of anywhere from a few hours to a week or two in the use of the computer, and then to put them to work using it on the job, with support when they ran into problems. After some weeks or months, the employees "got up to speed."

For new workers the approach has been to incorporate computer training into the total training program for the job, so that some additional hours or weeks of computer training are built into a skill training program that might take anywhere from a few weeks to more than a year.

For occupations in which the worker has to be fluent in use of the computer before beginning to work (for example, airline reservation agents), the procedure has been to provide a long enough training period before the trainee comes into the job, rather than relying on learning while working.

A wide variety of training methods are used in employer training programs. Group instruction is probably the most common. Self-study programs using manuals or textbooks are common, sometimes for home study, but often for study while on the job, in special training facilities when the workplace is not conducive to study. Some companies use purchased computer-based teaching materials, including both terminals and videodiscs.

Employer-provided training in computer skills, like all employer-provided training, is a cost to the company, both for instructors and materials and because the company is paying for the workers' time. It therefore emphasizes training geared narrowly to the specific job needs and compressed into a minimum amount of time. It also makes maximum use of the opportunity to give the learner practice in the work on the job, so that the skills are learned quickly and effectively.

A company training program for computer skills may be illustrated by the program of a public utility in an East Coast city. This company does its own computer training, rather than send employees to programs provided by vendors of equipment. They have self-study for some groups of workers, including programmers (three month training period), people in such departments as engineering and finance who need to learn to use microcomputers (three to five days), and people who need to learn word processing (two to three days, plus an advanced course of the same length). Classroom training is provided for people in departments who do computing on the mainframe computer using terminals; the training is given in two steps—one week of initial training and a second week after the workers have six to twelve months of experience. Systems analysts normally move up from the programming staff after some years of experience.

The company training program of one large manufacturer of computer equipment exemplifies a substantial commitment to the training of its employees. The number of days of training given in the course of a year averages 10 days per employee; while much of the training is concentrated among new workers, the company's policy is to see that all engineers, programmers, and technical writers get five days of training every year. Programmers, for example, are currently hired with some computer science courses in college; a series of courses are selected for each employee by his or her supervisor, adapting the training to individual needs, so that in the first five years of employment these employees average about 15 days of training a year in courses of three to five days. Engineers get somewhat less formal training, since they come into the company with degrees in their field that make them productive more quickly; nevertheless the company encourages continuing education to keep up with their fields, sends them to graduate schools with tuition aid, and also gives some university-level training in the workplace.

Salesworkers in this company are trained by self-study in branch offices, then go to the company's education center to learn computer concepts and marketing; this is followed by another five to nine weeks of training in a branch office, during which they go out with experienced salesworkers to make calls on customers and learn how to design a computer system for a customer in a case-study program; they go through a three-week course in marketing at the company's national training center; then to three weeks of training in designing a computer system; this is followed by a self-study period, and then a school in which the salesworker learns design of a system for one or another industry (such as manufacturing, distribution, a process industry, finance, etc.). By the time the salesworker has been with the company a year and has been through all this training, he or she is given a territory and can go out and sell.

Most company training programs are a good deal less elaborate; as with employer-provided training generally, it is the large firms that are most active in training.

g. Computer Equipment Manufacturers

In addition to providing training for their own employees manufacturers of computer equipment provide training for employees of companies buying their equipment. There are no statistics on the volume of this training, but our interviews with people in the various occupations that use computers in their work suggest that this is a major mode of training, if not the most important one. Some of the computer manufacturers issue catalogues of courses offered; one of these lists 660 separate courses or training programs. Subjects in which training is provided include the operation of computers of various sizes with already-prepared programs, programming, maintenance and repair, systems management, other management problems associated with computers, communications systems, and operation and programming of computer-assisted design or manufacturing equipment.

The courses provided to employees of companies buying equipment are typically brief, lasting from one to five days, although some courses go on for several weeks. They tend to be quite specific, focusing on a single model of equipment, use of a single program, or teaching a single programming language.

Self-study is used extensively. Textbooks, programmed learning books, and computer-based training programs are available for many of the subjects. In some cases computer-based programs use video equipment for training in such subjects as computer maintenance and repair to enable the student to see the equipment being discussed.

Courses are given in training facilities operated by the manufacturers in major cities throughout the country or in the customers' own facilities. Tuition varies widely in the range of about $100 to $400 per day, depending on such factors as expected class size and equipment used. Some courses are furnished without charge. These include training for a few employees of a customer who has just purchased equipment and courses, designed for executives of prospective customer firms, on the potentialities of computer application to various business uses; the latter are considered marketing expenses of the computer company.

Computer manufacturers have varying policies with respect to providing customers training free of charge. Competitive pressures encourage them to offer free training, and the manufacturer has everything to gain in customer satisfaction if the customer's employees become productive on the new equipment quickly--an important consideration in selling to business firms, which are always a potential source of repeat business. Yet all recognize that the cost of free training has to be included in the price of the equipment, and this could create inequities among customers who use different amounts of such training. Moreover, if training is a cost of doing business there is always the potential pressure to skimp on it when the company needs to reduce operating costs, and this could have adverse effects on customer relations and satisfaction. For these reasons some of the major computer manufacturers are shifting more to the policy of charging tuition for all courses.

h. Professional Associations and Labor Unions

Professional associations and labor unions are composed of member practitioners or workers within a particular occupational group and are aimed at advancing the interests of the occupation as a whole as well as enhancing the occupational competence of its individual members. These groups are organized on a national, regional, state, or local basis and consist of such diverse members as engineers, real estate brokers, doctors, secretaries, and machinists. In the area of continuing education and training, they serve their members through meetings and conferences, professional publications, workshops, courses, and other educational activities. These activities are almost always part-time and are usually paid for by the participants, their employers, or the union.

Despite the absence of statistics on the number of computer-related courses or programs offered by these groups, it is evident that they are increasingly offering seminars and workshops, as well as longer courses, in the use of the computer and its specific applications to the particular occupation. As an example, The American Bankers Association, through its American Institute of Banking in New York, offers courses in programming fundamentals, bank data processing fundamentals, financial planning with an electronic spreadsheet, and bank records management with a microcomputer. In addition, the Institute operates a microcomputer laboratory with an extensive software library for the use of its students.

The American Management Associations, National Association of Realtors, and the National Shorthand Reporters Association are representative of the diverse professional groups offering their members training in the use and application of the computer in their occupations. In 1978, participants in adult education indicated that they took 8,000 computer-related courses provided by a professional association or labor union.

i. Other Training Sources

In addition to the training activities described above, there are a variety of computer-related programs available through federal, state, and local governments and organizations.

At the federal level, the Job Training Partnership Act (JTPA) and the Trade Act of 1974 are the main sponsors of training for disadvantaged and dislocated workers. Programs, developed and operated at the state and local level, are supposed to be designed with an emphasis on training in fields where job openings are increasing and include secretarial/clerical work and computer sciences, although specific data on numbers trained are unavailable.

Since 1980, local partnership programs have enjoyed increasing currency as the preferred locus of responsibility and service deliverer for government training programs. These partnerships take a variety of forms but, in almost every case, include the involvement of one or more major employer(s) in the community. The presence of the employer is designed to assure that training programs are up-to-date and provide training in skills needed for current or projected jobs in local industry and businesses.

An example of one major federal computer-related training program is the network of word processing training centers currently operating in 32 cities across the country. These centers are run by local community-based organizations in partnership with the IBM Corporation, with additional funding from JTPA. Training in word processing, computer operation, and computer programming is provided to approximately 3,000 individuals annually. The training is done on up-to-date equipment, lasts for 26 weeks, and consists of six hours a day, five days a week. While no stipend is offered to trainees, they do receive $35 a week to cover transportation, and other support services, including counseling, are provided. Twenty-three new centers are being added to the national program by June 1, 1985.

An example of a state computer-related training program is the Bay State Skills Corporation (BSSC), created and funded by the Massachusetts legislature in 1981 to act as a catalyst in forming partnerships with business and education to train workers in skills needed by growing industries in the state. The programs cover a variety of training levels, including entry-level training, employee upgrading, retraining, and advanced (college- and university-level) programs, and run from 20 weeks to 20 months. Training is provided in a wide variety of new and emerging occupations, such as nuclear medicine technology, and advanced automation and robotics, in addition to the more traditional occupations of the machine trades, licensed practical nursing, and junior accounting. The training takes place at community colleges, vocational schools, four-year colleges, universities, and community-based employment and training organizations throughout the state.

In addition to federal and state programs, many local governments and community organizations run low-cost, introductory computer courses which are offered at libraries, YMCAs, and other community locations. The Tacoma (WA) Public Library, for example, offers free classes in computer literacy, programming in BASIC, and selected microcomputer applications. Courses are available to persons 18 years old and older and are held once a week for four to eight weeks. Fairfax County (VA) offers a course in "Computers for the Medical Assistant." The class, which meets weekly at a local high school for five weeks, explores the use of automation in the doctor's office. Another course covers the coding system being implemented in hospitals, insurance companies, and doctors' offices. Classes are held at night, and costs are very low.

In summary, while the figures on formal training programs, enrollments, and completions are incomplete, they do provide evidence of a wide variety of providers of computer-related training and a growing number of opportunities for workers interested in obtaining skills in the use of computers. It is likely that employers will continue to provide the majority of computer-related training on the job, while two-year and four-year colleges and universities increasingly provide training in the use of computers as part of their educational programs.

2. Financing of Computer Training

It was not possible through the interviews to get information on the number of workers in any occupation who learn their computer skills by each method, or on the cost of training, and so we cannot quantify the distribution of financing of computer training among the main sources of funding--employers, the public, and the workers themselves.

A great deal of the training is done when the worker is already employed--by the company's own training staff, by trainers employed by vendors of computing equipment, or by schools or professional associations. Vendors provide some training free of charge to purchasers of equipment but generally charge tuition for their training programs. In both cases the purchaser pays, since the cost of training provided without charge has to be included in the price of the equipment. When employees are trained in schools or by professional associations, the employer frequently pays for the training through various tuition aid arrangements. Employers, therefore, are a major source of funds for computer training.

Schools at several levels provide computer training both before employment and to persons already employed. Tuition is charged except in public secondary school vocational education programs, but since few publicly-supported or privately-supported institutions have all their costs defrayed by tuition payments, the public, either through taxes or through contributions to private colleges and universities, supports some of the cost of computer education in the schools. The individual who is not yet employed pays the tuition for courses taken, and some employed workers pay all their tuition or, in some tuition aid arrangements, share the cost with employers. Employers pay the full cost in other situations. The cost of computer training in schools is, therefore, shared among the individuals, the employers, and the public.

For professional workers, computer training is becoming part of the curriculum in college and university programs; the effect of this is to shift some of the costs of training to the individual and to the public. But since the use of computers is growing rapidly, there will continue to be groups of professional workers who did not have this training in their college years but whose jobs begin to require it, and so employers will be paying some or all of the cost of training. Moreover, technology is changing, requiring occasional retraining of employees, a cost usually borne by employers.

III. POLICY ISSUES

The findings on the training required by people who work with computers may be helpful in considering a number of policy issues in education and training.

A. Role of Schools in Computer Education

We have found that, except for the comparatively small numbers of workers who require extensive computer-related training and the professional and technical workers who learn programming and other computer use in the course of their college or university training, most people who work with computers have been trained on the job by their employers or sent by them for training to equipment vendors, professional associations, or schools.

This may be an accommodation to the fact that with the rapid introduction of computers, incumbents of jobs have had to be trained quickly. If so, the question arises whether there is a greater role for schools in the future in training for workers who use computers, but are not required to program them, at what level of the educational system, and for which computer-related skills.

We noted two kinds of computer-related skills that schools are already teaching effectively: word processing (which may ultimately be taught as part of typing courses) and electronic and computer technology. Secondary and postsecondary schools may assume a greater role in these kinds of training.

For occupations which do not do programming or word processing and are not involved in maintenance of computer and electronic equipment (that is, the great majority of workers who operate computers, using a keyboard, as a tool in their work), the computer skills can be learned quickly. Since a variety of equipment and software are in use, there are advantages to learning on the equipment they will be using in their jobs and the specific tasks they will be doing. This favors on-the-job training, the principal mode of learning now followed. As long as computer use continues to grow rapidly and new models continue to come out, on-the-job training will continue to be a major way in which the skills are learned. Experience and familiarity with computers undoubtedly help in this learning process--whether the experience is in other jobs, or in computer-assisted instruction in school subjects, or hands-on experience in a "computer literacy" course. But even for people without experience the learning is so rapid that experiences of the kind mentioned do not speed up the learning significantly. Employers who have instituted programs of on-the-job training will probably assume that all new workers have to go through the program, whether or not they have some of these kinds of computer experience. Most training programs are designed to impart all the skills required in the job, of which computer skills are a small part, and there is little chance that trainers or supervisors would excuse from minor parts of the program those workers who claim to have had relevant computer experience.

There are other occupations in which school-based training programs in a computer skill may provide a competitive advantage, including some of the technician and repair occupations for which technical school training in electronics provides a good base for learning.

Another situation in which schools can give computer-related training effectively is where it is part of a general program for training in all aspects of the work of an occupation--for example, calculating and other office applications should be taught in courses in bookkeeping and accounting methods. Applications in the building trades, such as construction management and cost estimating, should be taught as part of the vocational curriculum in this field. The ways in which computers are used and how they relate to other aspects of the craft or profession are a substantial body of knowledge, and an important part of training for the occupation, while the keyboard operating skill itself is quickly learned and hardly worth the trouble to take training for it in school. Schools emphasizing the use of the computer as an occupational tool make a significant contribution to training for work.

There still remains the question of general education about computers for all youth, which is sometimes discussed under the rubric of "computer literacy." This report, which is focused on the training required for work with computers, does not try to evaluate what should be taught about computers as a contribution to general education. Nevertheless, some findings of this study may be helpful to those planning computer literacy education. On the basis of the finding that no more than two percent of all workers need to be able to program computers, a question might be raised as to whether computer programming should be part of a general computer literacy studies program for the population as a whole. Its inclusion could only be justified on general educational grounds - for example, if it has value as a discipline or conveys an understanding of the logical foundations of computer technology. There are some precedents for this: despite the small percentage of workers who use them in their work, geometry and foreign languages, for example, are in the general curriculum, justified mainly on their educational value rather than as preparation for work.

One other comment may be relevant to the issue of computer literacy education. There is a substantial effort in the elementary and secondary schools to introduce computer-assisted methods for the teaching of school subjects. In schools where this becomes prevalent, children will get some experience in operating computers with keyboards and some understanding of what computers are like and what they do. These, of course, are some of the goals of most plans for computer literacy education. In this respect, success in developing computer-assisted teaching reduces the need for computer literacy education.

As schools consider what approach to broad computer literacy education they will follow, they must, of course, consider the trade-off between the benefits and the costs, which include taking the limited time of students and the limited resources of schools. What is involved are trade-offs in educational emphases. In trying to give students the best foundation for dealing with this particular technology, they may want to consider how students can best be prepared to deal with technological change in general. Important components of such learning may include literacy, facility in learning new subjects, and study skills, and a broad understanding of the scientific and humanistic base of various work technologies--physics, mechanics, chemistry, biology, mathematics, social sciences, and language. It is in relation to the total education of youths to deal with technological change that the need for and content of computer literacy instruction can best be evaluated.

The schools have an additional role in relation to education about the computer: their responsibility to provide vocational guidance and counseling. Accurate and realistic information should be provided to students about the computer training requirements in the various occupations, to counteract some of the misinformation that is widely current. The information in Chapter IV of this report may be helpful in this respect.

B. Retraining Displaced Workers

One of the concerns in policy discussions revolving around the invasion of the workplace by computers has been whether workers displaced by computer technology--or indeed by any other factor, such as foreign competition that has hit the automobile, steel, textile, apparel, and shoe industries--can and should be retrained in "high tech" occupations such as work with computers--a measure designed to reduce structural unemployment.

Questions have been raised as to the feasibility of large retraining programs of this kind: do the new jobs require higher educational levels than the displaced workers possess, and if so can their educational deficiencies be made up? Are the displaced workers in the same geographical areas as the "high tech" industries, or are they or the industries willing to move? Are there enough jobs to accommodate them--or those of them who are able to benefit from the training and move to the jobs? Despite the popularity of the buzz word, "high tech" industries and occupations involve a relatively small number of jobs (Richie, Hecker and Burgan, 1983).

A relevant finding of this study is that for most computer-related jobs (all, in fact, but the few created by the computer itself, such as programmers, systems analysts, computer repairers, computer operators, and data entry keyers), the computer skills required are but a small part of the total skill content of the jobs. Retraining programs, therefore, cannot focus on computer skills alone--unless they are to train for the one percent of all jobs included in the computer-created occupations themselves--but rather have to be designed to give trainees the full range of skills needed in occupations in which they are to seek reemployment. Displaced workers who already have all the skills required for a job except the computer skills should have no trouble in getting any jobs that are open; experience has shown that employers are willing to hire workers who otherwise have the job skills, and equip them with needed computer skills by putting them through brief training programs. It would not be necessary for government agencies or communities to set up programs to accomplish this.

C. Training Programs of Vendors

The large training enterprises operated by vendors, mainly manufacturers of computer equipment but also including software companies, offer courses and training materials (textbooks and software for computer-assisted training) for fees, but manufacturers also commonly provide some free training to the employees of firms that buy equipment. Vendors have to face a number of policy issues with respect to their training programs, and their decisions have a bearing on the training policies of both the companies who are customers and the schools.

Giving free training to customers is not only a sales inducement but also helps to assure that the equipment will be efficiently used and therefore promote customer satisfaction and lead to repeat business. There are a number of questions the vendor has to decide, however, including how many employees of a customer should be given the free training; how long should it be given for each purchaser--e.g., whether it should be given to employees hired to replace those who have been trained and then left their jobs; whether giving free training encourages customers to send less able employees than if they had to pay for the training; whether giving free training (the cost of which has to be included in the price of the equipment sold) does not make customers who require less training bear part of the costs for those who require more; whether it makes the price of equipment less competitive; whether there is danger that the equipment manufacturer's policy officials will see the training program as a burden to be skimped on when the business situation deteriorates, with an inevitable effect on customer satisfaction.

Companies trying to be restrictive in offering the free training have to be concerned that competitors may be more generous. Similar considerations affect the decisions on the fees to charge for training; as noted above, there is a wide range among vendors in tuition fee schedules per day of training. Still another issue is the question of how long to offer courses relevant to older equipment when substantially different new models have been introduced.

Many of these problems disappear if the vendor follows a policy of charging fees for all training and setting the fee schedule so that the training enterprise is self-supporting. But considerations of customer relations do enter and require some subsidization of the sales department by the training department.

The pricing policies for vendor-provided training affect both the in-house training policies of customers and the programs of schools and colleges. If vendor-provided training becomes expensive, the other providers will be under pressure to expand their services.

D. The Choices for an Individual

The individual who is not employed, whether in school or looking for work, has to consider whether taking some training in computer skills would be useful in getting a job and building a career, and what kind of training would be most helpful.

The descriptions of computer use and training in many occupations in Chapter IV of this report will give some guidance on this question. They indicate the kinds of computer training needed, and whether employers expect to give the training themselves or are looking for job applicants who already have some relevant training or experiences.

Two points frequently emphasized in the many interviews were: (1) for most occupations the computer skill is a small part of the total skill requirements in the occupation and (2) computer operating or programming skills may be introduced in a classroom but are only developed by experience in doing the work.

The first point strongly suggests that the person preparing for work in an occupation should give the greatest attention to developing all the work skills required in that occupation, and should not allocate too much time or invest too much money in learning the computer skills alone. For example, for secretarial work it is important to develop the variety of skills, including language skills, required in the job; word processing and other computer skills are learned easily compared to the others. Similarly, an accountant or an airplane engine mechanic should devote most time to the non-computer skills of the occupation.

The second point implies that if the individual takes a computer training course it would be best to select one that provides a great deal of time for practice. This is true whether it is a course in programming (required in a limited number of occupations) or in operating the computer, as in word processing. If instead of taking a formal course the individual chooses to study programming, word processing, computation, storage and retrieval or other computer skills from a manual, it is essential to have access to a computer for long periods of time to practice.

It goes without saying that the kind of training one takes should be geared to the kind of work one expects to do. In programming, for example, it is important to learn a language appropriate to the applications one will be working with. In word processing it would save time in re-learning if the individual learns to use a program and equipment similar to what is used in the workplaces where he or she will be seeking a job.

E. Looking Ahead

The finding that widespread use of computers in work will not impose correspondingly large demands on the education and training system may be surprising to some, but it should be reassuring particularly in view of the unusual nature of this technological innovation.

That this is an extraordinary innovation there can be no doubt. Most new technologies affect not much more than a single industry or occupation, even though they may have profound effects on our lives. Examples that come to mind are the sewing machine, radio and television, and air conditioning. Some few others have a broader effect on other industries, as has the automobile, which affected other forms of transportation and such industries as rubber, glass, highway construction, and tourism, as well as the distribution of population around cities. But few innovations have had as pervasive an effect as the computer on the way work is done in all industries and by people in many occupations. In this respect the computer's effects may be compared only to such immense innovations as the use of power machinery, which initiated the industrial revolution.

In view of this, it is natural that educators and industrialists should have anticipated major demands on education and training institutions to equip the work force with new skills. To make the system responsive, secondary and postsecondary schools, public and private, have introduced new courses, developed and tried to define the concept of computer literacy, and adopted requirements for computer skills in the training and certification of teachers in some states.

It may come as a surprise to many, therefore, that when the skill requirements for work with computers are ascertained in specific and concrete terms, as was done in this study, it should be found that by far the majority of workers involved can learn the skills quickly with brief formal or informal training by employers, and that no large burden will be imposed on the educational system to prepare students for work in the computer age. The burden on the educational system will be centered on a few sectors: departments of electrical and electronic engineering (and related basic sciences) and departments of computer science in the colleges; and the teaching of such subjects as electronics, typing skills, and business and accounting practices in vocational and technical schools. Some additional workload will be taken on by the schools if they develop computer literacy teaching as a component of general education. The revolutionary new technology will not drastically change education, as far as can now be seen.

We should remember, however, that while the computer revolution has gone beyond its infancy, it is still in an early phase, and as the technology advances (artificial intelligence is still under development, for example), and as computer use spreads to other applications, new and different educational implications and policy issues may emerge. This could be well into the future. When automobiles first frightened horses on city streets, who could have predicted - with enough assurance to base private action and public policy - that 80 years later, millions of new jobs would have been created, suburbs would have grown, central cities decayed, and the great railroads rusted? Similarly, vast unforeseen effects may follow from the computer, and to be forewarned we must closely watch emerging developments.

IV. TRAINING REQUIRED IN INDIVIDUAL OCCUPATIONS

List of Occupations for Which Training is Described

The 75 descriptions listed here include a number of broad groupings such as engineers, social scientists, health technicians, and "other clerical occupations." Table A-1 in the Appendix lists in greater detail the 140 occupations in which computers are used.

PAGE

GROUP I: OCCUPATIONS REQUIRING EXTENSIVE COMPUTER TRAINING

Computer Programmers 43
Computer Sciences Teachers, College 44
Computer Systems Analysts 44
Data Processing Equipment Repairers 45
Programmers, Numerically-Controlled Machine Tool 46
Repairers of Numerically-Controlled Industrial Equipment 46

(Training required by engineers in computer manufacturing is described under Engineers.)

GROUP II. OCCUPATIONS IN WHICH SOME WORKERS MAY REQUIRE TRAINING IN PROGRAMMING COMPUTERS AS WELL AS OPERATING COMPUTERS

Engineering and Related Technical Occupations

Engineers 48
Engineering Technicians and Technologists 49
Surveyors and Surveying and Mapping Scientists, Technicians, and Technologists 50

Life and Physical Scientists

Biological and Agricultural Scientists 51
Chemists 51
Geologists 52
Geophysicists 52
Meteorologists 52
Physicists 53

Mathematical Scientists

Actuaries 53
Mathematicians 54
Statisticians 54

Other Professional and Technical Workers

Accountants and Auditors 54
Architects 55
Dietitians 56
Elementary and Secondary School Teachers 57
Extension Service Specialists 58
Foresters and Conservation Scientists 58

- Medical Record Administrators 59
- Social Scientists 59
- Urban and Regional Planners 60

GROUP III: OCCUPATIONS THAT MAY REQUIRE TRAINING IN OPERATING COMPUTERS

Engineering Technicians

- Broadcast Technicians 61
- Drafters 61
- Estimator-Analysts, Electric Utilities 62

Medical Workers

- Health Technicians and Technologists 62
- Licensed Practical Nurses 63
- Medical Record Technicians 63
- Pharmacists 64
- Physicians 64
- Registered Nurses 65

Other Professional and Technical Workers

- Air Traffic Controllers 66
- Airplane Pilots 66
- Commercial and Graphic Artists and Designers 67
- Industrial Designers 67
- Lawyers 67
- Legal Assistants 68
- Librarians 69
- Library Technicians 70
- Purchasing Agents and Managers 70
- Reporters and Correspondents 71
- Technical Writers 71
- Writers and Editors 72

Managers and Administrators 72

Sales Workers

- Real Estate Agents and Brokers 73
- Sales Representatives, Computer or Software Manufacturing 73
- Securities Sales Agents 73
- Travel Agents 74

Clerical Workers

- Airline Reservation Agents 74
- Bank Tellers 75
- Bookkeepers and Accounting Clerks 75
- Cashiers 76
- Computer and Peripheral Equipment Operators 76
- Data Entry Keyers 77
- Directory Assistance Operators 77
- Postal Clerks: Letter-Sorting Machine Operators 78
- Secretaries 78
- Stenographers and Shorthand Reporters 79
- Traffic, Shipping, and Receiving Clerks 80
- Typists and Word Processing Machine Operators 81

Other Clerical Occupations 82

Craft and Industrial Process Workers
Aircraft Mechanics 82
Central Office and PBX Technicians 83
Chemical Plant Operators 83
Electric Generating Plant Operators 84
Graphic Arts Occupations 84
Pattern Graders and Layout Workers, Apparel and Shoe Industry ... 85
Petroleum Refinery Operators 85
Systems Operators or Dispatchers, Electric Utilities 86

Farm Operators and Managers 86

Group I: Occupations Requiring Extensive Computer Training

Computer Programmers

Programmers write the instructions a computer follows. There are two types of programmers: systems programmers and applications programmers.

Systems programmers, working for computer manufacturers, write the instructions for the internal operating system of a computer. They have to understand the architecture of the equipment and write in assembler language. In this work emphasis is on designing the program for maximum efficiency, and a high degree of sophistication is required; the best and most creative programmers are assigned to systems programming.

Applications programmers, on the other hand, write programs for a special purpose; they are fed into the computer on a disk or tape which can be removed and another applications program substituted. Applications programs may be developed for a single purpose (such as a statistics processing program for a statistics collection agency, a sales records and inventory control program for a department store, a program for a complex scientific calculation, or a flight and reservations recording system for an airline), or they may be developed for general application such as word processing, business accounting, or statistical programs that are marketed to users of computers. Many of the programs used are written by members of other occupations who have learned programming rather than by professional programmers.

Applications programers may start with a plan developed by a systems analyst, or they may originate the plan themselves; they write the detailed steps required to do the work. The instructions to the computer may be written in an assembler language or in a high-level program language, such as COBOL (used for many applications in business), FORTRAN or PL/I (used for scientific or mathematical applications), or BASIC. Programmers test the completed program, and when it has been checked out they also write instructions to the computer operators who will run the program.

There are no standard training requirements for programmers because employers' needs vary. Courses in programming are offered in vocational schools, community colleges, four-year colleges, and training programs run by computer manufacturers. Colleges provide undergraduate or graduate degrees in computer science, which qualify students for advanced work and for systems programming. Training for applications programming does not require a degree in computer science; for example, a comprehensive 11-week course offered by the graduate school of the U.S. Department of Agriculture is said to "enable people without previous data processing experience to qualify for positions as entry-level COBOL programmers." A person already experienced in programming with one language can learn another language in a course as brief as five days, followed by a period of practice in programming with the new language. Two thirds of the programmers got their training in schools - 40 percent in 4-year colleges and 19 percent in junior colleges or technical institutes. Informal on-the-job training was received by 41 percent, and formal employer-provided training by 19 percent (Appendix Table A-8).

For people already employed, one or more brief courses, each followed by intensive experience, has been found to be an effective way of learning applications programming. It may take several months under close supervision before a programmer can handle all aspects of the job, and it takes several years of experience for a really skilled and creative programmer to develop. Many applications programs have been written by people whose main training has been in other occupations; they learn by taking courses in programming, or just by picking up the skills by experience. Some of these remain in their professional fields, while others go into programming as a full-time career.

Organizations like to hire programmers for applications programming with strong backgrounds in the fields in which the computers are being applied; that is, for management or accounting applications, programmers with business school education are preferred; for engineering, scientific, or statistical applications, programmers with the appropriate backgrounds are desired. This is one reason why members of other occupations have become programmers. In recent years as computer science graduates have been coming out of the colleges in increasing numbers, employers have been turning to this source for more of their programming trainees.

Computer Sciences Teachers, College

The members of computer sciences faculties at colleges and universities at one time came into the field from related fields such as physics, mathematics, or electrical engineering. In recent years, several hundred doctorates in computer sciences have been awarded annually, and most new faculty members in university departments of computer sciences have had this training.

The number of PhD's in computer sciences has not been adequate to meet the total need for teachers. In an effort to meet the demand on an emergency basis, smaller liberal arts colleges have called upon members of other departments, such as mathematics, to give the courses and have paid for training to enable them to do so. In one program, for example, developed under the joint sponsorship of the Mathematics Association of America and the Association for Computing Machinery, eight of the basic courses in computer science are given for college faculty members in two eight-week summer sessions, and in the intervening academic year participants are required to undertake a complex programming project and to teach one course in computer science.

Computer Systems Analysts

Systems analysts begin with a problem: what does the client want to accomplish? They design a complete system of data processing, including not only what the computer does and what kind of computer and related equipment is needed, but also how data are collected and fed into the computer and how the results of the computer's work are produced in such a way as to be useful. The specification for the work designed for the computer itself is then given to computer programmers, who translate the general design into specific instructions to the computer.

While some systems analysts begin as programmers, most come into the field from other occupations, because of the importance of understanding the context in which the system operates. Often their experience is in the functional areas of the organization, in accounting, engineering, offices procedures, a scientific field, statistics, or other areas of work for which computer systems are to be designed. Two-thirds of systems analysts got their training in schools - half of them in four-year colleges. Two thirds also got training on the job - mostly informal training (Appendix Table A-8).

In addition to understanding the subject matter of the tasks for which the system is to be designed, systems analysts need to understand data processing and equipment. Courses in computer concepts, systems analysis, and data base management as well as some training in applications programming are helpful in learning this work. Keeping up with the field is necessary because of constant technological change; from time to time systems analysts have to take short courses offered by equipment manufacturers or software producers on systems management, new equipment, and software. Twenty-one percent took courses in schools, 36 percent took formal training from employers, and 24 percent informal training (Appendix Table A-8).

Data Processing Equipment Repairers

These workers are sometimes called computer technicians, customer engineers, or field engineers. The equipment they maintain and repair includes central processing units, terminals, storage units, and printers, and the connections between them.

In trouble-shooting, the repairer uses instruments such as voltmeters that tell what parts of the equipment are not functioning properly. The newest computers have diagnostic devices built into them or can be plugged into diagnostic equipment, sometimes by telephone. Repair can frequently be done by replacing the malfunctioning component.

The basic training required is in electronics, which can be learned in technical institutes, community colleges, colleges, or the Armed Forces. More than half the repairers got training in schools, mostly in technical institutes and community colleges and postsecondary vocational schools; 22 percent were trained in the Armed Forces; and 60 percent also got training from employers (Appendix Table A-8). Some repairers get into the field after experience in business machine or television servicing, or as engineering technicians. Newly hired repairmen usually receive from three months to a year of training, including formal classroom training, self-study or computer-based training, and on-the-job training. The programs include basic electronics, computer theory and circuitry, as well as intensive short courses on maintenance and repair of specific models of equipment.

In order to learn to repair different models or types of equipment and to keep up with fast-changing technology, they have to keep taking short courses throughout their careers; more than half reported taking formal company-provided training to improve their skills (Appendix Table A-8).

Programmers, Numerically-Controlled Machine Tool

Tool programmers write the programs that direct a machine tool to go through the steps required to perform a specific machining job. Programmers must have broad knowledge of machining operations, mathematics through trigonometry, blueprint reading, the working properties of various metals, and the use of precision measuring instruments.

Programmers begin with a blueprint. They outline the sequence of machine operations required and select the proper instructions for the machine, convert into programming language, and encode the program on paper tape, punch cards, or magnetic tape. The programmer then writes a list of instructions for the machine tool operator. Computer Numerical Control equipment incorporating a computer, which is rapidly replacing the previously mentioned formats, provides a more efficient transition from the part drawing to the machined part.

Employers prefer to promote or hire skilled machinists for tool programming jobs. To learn tool programming the worker takes courses at vocational schools, colleges, or community colleges, some paid for by the employer, in other cases by the worker. Manufacturers of numerically-controlled machine tools provide training for employees of firms that buy the equipment.

The training may be illustrated by one course, sponsored by the International Association of Machinists, conducted at a four-year college, with classes for 3-4 hours a week and an equal amount of time in practicing on computer-controlled equipment, for a period of 2-1/4 years. The students learn keyboarding, writing programs in BASIC, Computer Numerical Control coding, CAD/CAM, how to write a program to generate points, lines, and circles in languages such as APT (Automated Programmed Tools), or other computer-assisted programming software. The geometrical description generated is subsequently converted into information needed by the machine tool to produce the part. The interaction of CNC with other process technologies such as laser welding, electrical discharge machining, and related process technologies, is also taught.

Repairers of Numerically-Controlled Industrial Equipment

The electricians who install and/or repair programmable controllers (PC's) for numerically-controlled machine tools or other numerically-controlled industrial equipment are experienced electricians who have gone through an apprenticeship or other experienced wiremen (PE - pending examination) who need special training on the characteristics of this equipment.

Such training in installation, programming, and troubleshooting of programmable controllers may be illustrated by a program jointly sponsored and paid for by a local of the International Brotherhood of Electrical Workers and a local chapter of the National Electrical Contractors Association in Los Angeles. The curriculum consists of: an introductory course (18 hours - six weekly three-hour sessions) on the theory behind programmable controllers, solid state controls, and how the equipment works; a second course of the same duration on programming the PC and troubleshooting; and a third course (16-24 hours in eight-hour sessions on weekends) on installing, programming, and troubleshooting the major models of PC's now on the market. An entrance examination in motor controls is given, and electricians who do not do well on it are encouraged to take an introductory course in motor controls.

The course is primarily for journeymen electricians who may be called upon to do this kind of installation or repair. Large electrical contractors who specialize in this work and who do most of the PC installation provide in-house training to their own employees.

Only a small proportion of all electricians are called upon for this kind of work, but the use of PC's is growing, and the union is encouraging its members to equip themselves with the skills needed for the work (Office of Technology Assessment, 1984, pp. 436-448).

Group II. Occupations in Which Some Workers May Require Training in Programming Computers as Well as Operating Computers

Engineers

Computers are used by engineers in many different ways. All branches of engineering use them in making complex calculations. In addition, the individual branches use computers in a great variety of applications, which a few examples will illustrate. Civil engineers use them: to compute stresses and strains on structures; to design highways, making sure that curves are appropriate to expected vehicle speeds, and calculating the volumes of cut and fill required; or to make plots of subdivisions. Electrical engineers use programs that detail ducts and wiring; they also use computers to control electric utility systems, turning generators and other components on or off as required by power consumption. Mechanical engineers make computer analyses of energy flows and fluid flows within a system, and also use computer-assisted design (CAD). Chemical engineers use computers to analyze complex systems, determining the effects of heat, pressure, and changing chemical content on the speed of reactions. Biomedical engineers, one of the emerging specialties within engineering, use computers to design and build medical instruments and devices, such as artificial kidneys and hearts, cardiac pacemakers, and lasers for surgery as well as to monitor patients and to build systems aimed at modernizing laboratory, hospital, and clinical procedures. Computerized automatic control systems, increasingly used in chemical plants, petroleum refineries, and electric power generating and distribution, require the engineers to have computer technology competence to design systems, supervise their operation, and provide training for plant personnel (National Petroleum Refiners Association, 1982). Increasingly, design work, a major activity of engineers, is performed with the aid of computers.

For workers already in engineering, there are a variety of ways in which the necessary skills can be learned. Software is available for most of the applications frequently used by engineers. The training required to use these programs is given to engineers in 1-5 day seminars; from thereon the manuals and assistance from colleagues or by telephone from the software or computer producer are enough to carry the engineer through. Many engineers have become familiar with computers in engineering school, with or without taking special courses.

For work beyond what readily-available programs can do, some engineers learn to program in one of the high-level programming languages.

Engineering professional societies have comprehensive professional development programs, offering many short courses. Colleges and engineering schools also give courses for employed engineers. Much of this training is paid for by employers, but some is paid for by the engineer who wants to improve skills for advancement or job-shifting.

For new engineers, computer training is becoming more commonly available. Every student must be given appropriate computer-based experience while in engineering school, according to accreditation standards for the schools (Accreditation Board for Engineering and Technology, 1984). Students must be able to apply digital computation techniques to engineering problems - for example, problem-solving, technical calculations, data acquisition and processing, process control, computer-assisted design, and other functions appropriate to the field of engineering. As examples, mechanical engineering students must have substantial experience in computer applications in energy and mechanical systems; industrial engineers in programming in a high-level language such as PASCAL, FORTRAN, or APL, as well as simulation techniques; manufacturing engineers in the use of computers and microprocessors in control and operation of manufacturing systems, and in numerical and mathematical modeling; petroleum engineers must be able to apply computer proficiency in upper-level coursework.

For computer engineers there are, of course, more comprehensive special requirements: a strong mathematical foundation in differential and integral calculus, discrete mathematics, probability and statistics, and either linear algebra and matrices or numerical analysis; engineering science and design courses on hardware, software, application tradeoffs, and the basic modeling techniques used to represent the computing process; laboratory experience on logic design, system architecture, operating system software, and interactive computing; and proficiency in programming languages such as PASCAL, PL/I, or ADA, as well as understanding of assembler level language.

Engineering Technicians and Technologists

A group of occupations that has developed in the area between crafts and the engineering professions is engineering technicians or engineering technologists. They generally work with engineers, assisting them, or they do work requiring a high level of competence but so specialized that it does not require a broad engineering education. Originally these jobs were held by either high-school graduates self-taught or experienced in working with engineers, or persons who had a partial engineering education. As the occupations and their role have been recognized, formal educational programs have been developed, and the accreditation authorities have identified the kinds of quality and training needed.

The Accreditation Board for Engineering and Technology, Inc. (1984) has distinguished between educational programs for engineering technicians (two years of postsecondary education with an associate degree) and those for engineering technologists (four years, with a baccalaureate degree). At both levels, the accreditation standards state that it is essential that students acquire a working knowledge of computer usage in engineering technology, and that they be instructed in one or more of the high-level computer languages and taught problem-solving applications, as contrasted to traditional data processing - i.e. calculations.

Certain specialities in engineering technology, the standards say, should have appropriate computer-related courses: for example, in industrial engineering technology, simulation robotics, numerical control, and CAD/CAM; in manufacturing engineering technology, computer-aided manufacturing; and in computer engineering technology, programming in high-level and assembler languages, logic digital devices (including microprocessors), and computer architecture systems.

Surveyors and Surveying and Mapping Scientists, Technicians, and Technologists

Surveyors and related occupations measure the surface of the earth for a number of different purposes. Land surveyors measure land to establish boundaries for legal purposes or to enable engineers to plan construction. Geodetic surveyors measure large areas of the earth's surface, using special high-accuracy equipment, taking readings off satellites. Geophysical prospecting surveyors identify good places for prospecting for minerals or oil. Marine surveyors survey harbors, rivers, and other bodies of water to determine shorelines, depth, topography of the bottom, and other features. Cartographers use the information collected by the surveys to make maps. Photogrammetrists use photographs taken by satellites to make maps or learn the features of each area.

Electronic distance measuring equipment embodies computers, as do older instruments such as theodolites, and is used by surveying technicians to measure the distance, direction, and height of each point compared to another point. The technicians require some special training for use of the computer-modified equipment. The surveyor may use a computer in making calculations and for plotting survey information.

The work of the cartographer is changing. Techniques are being developed to store in a computer the information developed by surveyors by "digitizing" it - that is, expressing the lines that describe the features of the earth's surface in co-ordinates or the altitudes in colors that can be converted into digital information and stored in a computer record. Instead of making maps by manually tracing surveyors' original drawings, cartographers will be able to make maps from such digitized information, programming the computer to print out the maps.

Training requirements for surveyors now include skill in using computers for calculating, measurement, and plotting results. While the four-year course in surveying or in civil engineering with a speciality in surveying (both of which are given in civil engineering departments of engineering schools) may include some general education on computers and programming, not all surveyors have gone through such courses. Whether or not surveyors have had general computer education, the skill is commonly acquired by taking brief training provided by the computer manufacturer and following up by using a manual. Surveyors also frequently use computers in their office work for recordkeeping, billing, payroll, and other office functions; the training for these is the same as for calculating.

Surveying and mapping technicians and technologists are not required to have special computer training; they can use the instruments with minimum on-the-job instruction. Their main skills lie in knowing what to measure, in accordance with general instructions provided by surveyors and mapping scientists.

A change is taking place in the training required for cartographers. The federal government, their largest employer, is seeking persons with good training in mathematics and computer science and is prepared to give the required cartographic training on the job if necessary. Persons with professional training in cartography but no mathematics or computer science are not the preferred candidates for cartographer positions.

Biological and Agricultural Scientists

Biological and agricultural scientists use computers in research and in teaching. Primary use in research is in control of experiments and in processing data. Physiologists engaged in research use computers to model the complex and dynamic functioning of the living organism - for example, its reaction to a drug or other stimulus in terms of heartbeat rate, blood pressure, kidney functioning, and other variables. Computers are used in environmental research to model the ecology of an area. Another use is in processing and analysis of statistical data obtained in surveys of populations of organisms, or in counting cells under a microscope. In the agricultural sciences, computers are used, for example, in studies of crop yield under varying conditions of sunlight, rainfall, fertilizer, tillage, and other factors occurring at different points in the growing season. The computer is also used in teaching - for example, to simulate the response of an organism to various stimuli, as a substitute for a living animal, or to demonstrate graphically the functioning of an organ or of a whole physiological system. In addition, biological and agricultural scientists use computers for data storage and retrieval or for word processing.

The training required varies widely: most computer use involves only readily-available software or programs specially written by a technician or a colleague; but in many cases the scientist has to develop his or her own programs. There is no standard for the training in computer skills required: many students enter graduate programs with computer skill already developed; those who need more training select the computer courses they will need in consultation with their faculty advisor and take these courses in the computer science or mathematics department.

Chemists

Computers are used by chemists for a variety of purposes. Only brief training in use of the computer is required for such purposes as: literature search (the articles in the most commonly-used publication, Chemical Abstracts, are now indexed and stored in a computer); word processing; PROPHET, a graphic system that enables chemists to model and envisage the three-dimensional structure of molecules; and computer-controlled instrumentation such as is contained in magnetic resonance spectrometers.

More extensive training is required for the use of computers in research on molecular structure or reactivity; large-capacity computers are used and the chemist has to be able to program them in high-level languages such as FORTRAN and occasionally in machine language.

Chemistry departments are beginning to recognize that students need more exposure to computers. Courses on such subjects as "Numerical Methods in Chemistry" are offered in some departments. Students also take courses in computer science departments, and many enter college with knowledge of computer use and programming, or learn what they need by self-study. Many of those requiring advanced programming skills for research learn them on their own.

The guidelines for undergraduate professional education in chemistry issued by the Committee on Professional Training of the American Chemical Society in

1983 recommend that attention be given to computer applications in the core curriculum, and list advanced courses in computer science as one of the subjects that meet the minimum requirements for advanced work toward the BS degree in chemistry. The Committee recommended that students should emerge from an approved program with - in addition to certain training in mathematics and statistics - experience with computers, including programming, numerical and non-numerical algorithms, simulations, data acquisition, and use of data bases for information handling and retrieval (American Chemical Society, 1983).

Geologists

Geology, at one time considered to be a descriptive science, is using mathematical methods increasingly, and computers are used by geologists for computation, for data storage and retrieval, and for mapping. Oil and gas companies, the major employers of geologists, look for geologists with some computer training. While software is available for many of the applications used by geologists, a knowledge of programming in FORTRAN or other mathematics-oriented language is required for some computer work.

Students who have not acquired programming skills are advised by most geology departments to take one or more courses in the computer science department.

Geophysicists

Geophysicists require a strong background in mathematics and physics. Some use high-capacity mainframe computers in analyzing the shape, structure, and location of the various rock masses underground by means of seismic signals - vibrations made by earthquakes or artificial explosions. They have to be able to program computers for this kind of work--often in machine languages rather than the "high-level" computer languages used in less exacting programming.

Other geophysicists use smaller computers, often with packaged software, in such activities as modeling or hypothesizing various alternative possible structures underneath the surface, calculating the paths of synthetic seismic signals, and comparing the theoretical results with actual data.

Training in computer programming is a normal part of the curriculum in electrical engineering or physics, where most geophysicists get their training. Three or four courses in computing, including numerical analysis and advanced processing, are required.

Meteorologists

Meteorologists use advanced mainframe computers both in day-to-day weather forecasting and in research. Only a high-capacity computer can keep track of the many and constantly changing measurements (temperature, wind speed and direction, barometric pressure, water surface temperature, precipitation, etc.) at thousands of locations and at different altitudes. They may be able to use already-prepared software for some statistics calculations, but they have to do the programming for their principal use of the computer.

While there is no specification for computer training in the qualification standards for meteorologists issued by the federal government's Office of Personnel Management, the standards do call for 20 semester hours in meteorology, including six semester hours in forecasting, and this training requires learning how to program a computer. This is learned either through courses in computer science or by self-study. The National Weather Service provides focused computer training to its employees, with major emphasis on requirements of the National Meteorological Center.

Physicists

Both experimental and theoretical physicists may use computers in their work. In many cases the requirements for memory and processing speed are so great that only very high-capacity mainframe computers can be used. Other physicists, however, can do all their computer work using microcomputers either to control experiments or to do calculations, writing their own programs or using available software such as programs that perform symbolic manipulations.

While some ability to use computers is required of all students, training requirements are not uniform. Many students have already picked up the necessary skills by the time they begin formal training in physics; those without skills may be encouraged or required to take one or two programming courses in the computer science department, or the physics department itself will offer a course.

Actuaries

Actuaries combine the mathematics of finance with the mathematics of risk—the risk of death, sickness, injury, disability, unemployment, retirement, or property loss from accidents, theft, fire, and other hazards—to manage financial security programs such as casualty insurance, life insurance, and retirement plans. On the basis of their analyses, they make recommendations on plan provisions, price levels, reserve and surplus requirements, and investment policies for each kind of insurance. They conduct research on the persons or properties insured by their companies, using records stored on a mainframe computer. They also do research or modeling on smaller computers or time-sharing terminals, and may write their own programs for this purpose in such high-level languages as FORTRAN, BASIC, OR APL.

They require a thorough background in mathematics and statistics. Professional qualification is achieved by passing a series of examinations that qualify them as Fellows of the Society of Actuaries or the Casualty Actuarial Society. They may learn programming in high-level languages as students, or may be given brief (one week or less) formal training by their companies, or computer manufacturers, or companies that provide time-sharing services on their computers. This is followed by a period of learning while doing, in which they can get help from colleagues or supervisors.

Mathematicians

Mathematicians may use computers for writing, teaching, or research. The most common use is in word processing. In teaching, the computer, with or without graphics, may be used to illustrate a variety of mathematical concepts, especially in introductory courses in various fields of mathematics. In pure mathematical research, mathematicians sometimes use computers, for example, to generate sets of numbers from which conjectures about underlying theory may be developed. Newer equipment, together with a symbolic computer language such as LISP, makes it possible for mathematicians to do research involving symbol manipulation. In applied mathematics the computer's ability to handle large and complex calculations makes it a useful tool.

To use the computer for these research and teaching purposes, mathematicians have to be able to write programs in a high-level language such as FORTRAN, PASCAL or a structured BASIC, or in one of the symbolic languages such as LISP. Some learn through college courses in programming, others by self-study, since most computer concepts are understandable to someone with mathematical training.

Statisticians

Statisticians design and plan experiments or surveys; they analyze data already collected, and also develop quality control tests for manufactured products.

Computers are used in processing data collected in experiments or surveys and in analyzing data. The computer programs used to process survey data are usually designed especially for the particular survey, usually by computer systems analysts and programmers, but sometimes by statisticians. Statistical analyses of data already collected and processed, by such procedures as seasonal adjustment, measurement of sampling error, tests of significance, index numbers, and correlation, are generally done with software programs already available and do not usually require special programming. It is helpful to statisticians, however, to be able to do their own programming or to modify software.

Statisticians who use available software programs can learn how to do so by 1-or 2-day training or simply by studying the manual that comes with the software package. Those who have to learn programming do so by taking brief courses in programming languages such as FORTRAN and then learn by doing the work. Computer courses are required for graduate degrees in statistics.

Accountants and Auditors

Accountants and auditors examine, analyze, and interpret accounting records for the purpose of giving advice or preparing statements and installing or advising on the installation of systems of recording costs or other financial and budgetary data. These records and systems are increasingly computer-based, requiring familiarity with computers and their applications in both accounting and internal auditing.

Most employers require a minimum of a bachelor's degree in accounting, and virtually all accounting education programs include courses in automatic data processing, as well as computer-augmented accounting—using the computer and packaged software to solve accounting problems. This may involve keyboarding, balance sheets, recording, adjusting and closing entries, evaluation of inventory, depreciation, bank reconciliation, and computerized payroll systems. The curriculum may also offer an elective in programming (BASIC, COBOL, or other language).

At the graduate level, in such programs as an M.B.A./Certified Public Accountant or M.B.A./Certified Management Accountant, every student is required to take at least one data processing/management information systems course which teaches techniques for auditing a computerized system. While there are only a few degree programs specializing in internal auditing, virtually all of them require students to learn at least one programming language and to take at least one course in systems analysis. Internal auditors need the equivalent of a minor in computer science and in the application of computers to business in order to judge the effectiveness of the computerized system and its operation as well as the data and processes controlled by the system. An internal auditor must be capable of designing software to test and verify a particular system's controls and to recommend solutions where controls are found to be unreliable.

With the rapid proliferation of such computerized information systems, particularly in the last two years, and a shortage in the number of Certified Internal Auditors, many accountants are receiving specialized training in this area through professional associations and outside training organizations, usually paid for by their employers. The Institute of Internal Auditors, for example, offers week-long seminars in information systems auditing at a cost of $700-$800 which includes some hands-on experience using computer terminals and/or microcomputers. Upon completion of the seminar, the auditor is capable of implementing test programs immediately, although it does take some time to adapt to each company's individual system.

Some employers, such as the Big Eight public accounting companies, provide all their own training to their employees (e.g., Arthur Anderson sends employees to its own school in Chicago for initial training and for continuing education courses).

Single practitioners would be most likely to purchase their own computer and software, mainly electronic spreadsheets, and learn to use them on the job, with little or no formal training beyond any provided by the manufacturer.

Architects

Architects use computers in a variety of ways. Computer-aided design (CAD) (also called CADD — computer-aided design and drafting) is currently used in making architectural drawings, where repetitive work can be more easily done by the computer, using standard software called "detail libraries". More advanced software "integrates" these applications so that changes in drawings are automatically reflected in the specification. Emphasis is beginning to shift to aiding the decision-making process rather than simply replacing repetitive manual tasks with automation. The computer is also used in making and revising cost calculations, and in calculating the energy loss and heating costs for buildings of different design. Word processing is used in drawing up contracts and specifications and changing them as needed; specially-designed software for writing architectural specifications is available. Computers are also used for office management tasks such as payrolls, and for a wide variety of technical applications.

Larger architectural firms introduced computers early; smaller firms have purchased them extensively in recent years, as the microcomputer and software packages for architectural use became available, such as word processing programs adapted to writing specifications.

The training needed is primarily that required to use packaged software programs; architects occasionally program new applications.

Training for computer work is quickly becoming a standard part of the five-year curriculum for the Bachelor of Architecture offered in most schools of architecture or the six-year curriculum for Master of Architecture. Training for specific uses, such as word processing, cost calculation, or CAD, is given by equipment manufacturers or software producers in brief programs for employees of firms that purchase computers; training is also given by software producers or vendors of training. Much training is given in architectural offices via tutorials, instruction books, and audio cassettes. The American Institute of Architects has worked with architects who are expert in the field in developing a one-day education program on CADD systems, and a similar workshop on energy analysis using microcomputers. Those interested in acquiring programming skills to develop new applications of the computer to architecture may do so by self-study or by taking courses in one or another programming language.

Dietitians

Administrative dietitians manage large-scale meal planning and preparation in hospitals, prisons, cafeterias, schools, and other institutions. Increasingly, computers and packaged software are being used to order and keep track of inventories of food, equipment, and supplies and to prepare records and reports. Clinical dietitians are responsible for developing and implementing nutrition care plans and evaluating the results in hospitals, nursing homes, and clinics. They are likely to use computers to keep records on patient diets and personal nutrition-related data. They would also be likely to use word processing to issue their evaluations and reports.

Over 270 colleges and universities offer bachelor's degree programs for dietitians, and a large percentage of these offer at least one introductory course in understanding the computer and using it as a tool. Some programs include a course in a programming language as an elective, which may be particularly helpful to administrative dietitians dealing with large management information systems. The American Dietitian Association, which sets minimum requirements for becoming a Registered Dietitian, highly recommends that an inroductory course in using the computer be offered all students and be required of all administrative dietitians.

Elementary and Secondary School Teachers

With the increasing attention being focused on "computer literacy" and the ever-growing number of microcomputers being purchased by school systems throughout the country, the issue of computer training requirements for public elementary and secondary school teachers has come under much scrutiny of late.

In its recent report, Uses of Computers in Education, Education TURNKEY Systems found that computers in schools are being used for: computer-assisted instruction, with the student interacting directly with the computer; computer-managed instruction, with the computer serving as a support tool; education administrative applications, including attendance, scheduling, test scoring and other administrative functions; tool applications/instruction, such as word processing, graphing, and spread sheets; and the computer as the object of instruction, including orientation and programming. The report also states that at the elementary level, computers are used most frequently in math, followed by language arts and reading, while at the secondary level, computers are used most frequently in computer science, followed by math and business subjects (Education TURNKEY Systems, Inc., 1985).

Teacher-training programs relating to the use of computers are on the rise, both in-service and pre-service. Currently, 26 states either require or recommend that schools teach their students computer skills, which in turn leads to inclusion of such skills in teacher training. In a recent survey of state certification offices, two states reported a computer literacy coursework requirement for teachers. Twelve others reported a planned teacher requirement. States are requiring not only that new teachers learn basic computing skills before they enter the classroom but that experienced teachers, through in-service training, learn these skills as well.

As a result, a growing number of teachers' colleges and schools of education are incorporating into their curricula one or more computer-related courses. These may be a general introductory course to the use and application of the computer and available educational software or they may include learning a programming language (most frequently BASIC or LOGO). In addition, student teachers may also receive hands-on experience in using computers with students for computer-aided instruction during their teaching internships.

Teachers who are already in the classroom are receiving in-service training in the use of computers for drill and practice, teaching writing skills, word processing skills, and, in some cases, programming. Generally, when computers are purchased by, or donated to, a local school system, teachers are given an introductory workshop on how to access the computer and operate the software purchased with it. This introductory session is usually required for all teachers and includes both classroom learning and hands-on experience with the machine. By the end of the one-day training, teachers are expected to know how to access the computer and how to use a prepared program.

Many school systems are also offering teachers as part of in-service training (provided and funded by the system) more advanced courses in using computers. These include learning a programming language (most frequently LOGO at the elementary level and BASIC and PASCAL at the secondary level), using a particular software program, and adapting software to meet the individual teacher's needs. Such courses are usually offered after school at a centralized school facility (e.g. the computer laboratory at one of the system's high schools) and include group instruction as well as hands-on experience. A typical course may run once a week for three hours over a period of six to eight weeks, with teachers receiving credit for all courses taken.

For a detailed discussion of the uses and effects of the computer in education and the role of teachers, the reader is referred to another report sponsored by the National Commission for Employment Policy entitled *Uses of Computers in Education* (Education TURNKEY Systems, Inc., 1985).

Extension Service Specialists

Employees of the Cooperative Extension Service, who work in the U.S. Department of Agriculture, the land grant universities in the states, and the offices of county agents in farming areas, use computers in a number of ways. They use them in teaching, demonstration, and research, and in training farmers to use them; and some, especially the extension specialists at land grant universities, write computer programs for use in farm production and marketing management. In many states each county office either has a microcomputer or a terminal connected to a mainframe computer at the land grant university.

Extension service personnel get their computer training in several ways. Many learn operation of computers by self-study. Others take courses at land grant universities or other colleges, such as "Introduction to Computers." Those who do programming have picked it up by self-study or have taken courses in the computer sciences departments of colleges.

Foresters and Conservation Scientists

The forester trudging through the woods under a heavy pack may be gathering information for a computer. Probably less than half of all foresters and conservation scientists actually use computers, and only one out of ten of those that do have to learn programming; the rest use readily available programs. In addition to common office functions, foresters use computers for such specialized work as long-range land management planning. For example, they model timber growth, starting with the known stand of trees in an area and estimating growth as well as the supply/demand situation over the next few decades as a basis for planning cutting. A new electronic communications network with computing capabilities is being installed in the Forest Service, and hundreds of Forest Service employees will need training in its use.

Training in computer work is done by the company installing the communications system; some Forest Service employees are sent to other government agencies or to college programs for training. Most training programs take three to five days, but some are two-week programs. Many of the students coming through college programs in forestry or conservation science in the last few years have already acquired some computer knowledge. Those who have not may take college courses in the departments of computer science or mathematics.

Medical Record Administrators

The medical record administrator (MRA) is responsible for planning, designing, developing, evaluating, and managing health record systems to include administrative and clinical statistical data and health records in all types of health care facilities, organizations, and agencies. The MRA directs the medical records department and develops systems for documenting, storing, and retrieving the information it keeps. These systems are increasingly being computerized, particularly in large hospitals and other large health care facilities. In some settings, the MRA may be called on to create and develop different patient information systems which may involve actual programming or tailoring of existing software to the specific needs of the institution, rather than relying wholly on commercially available software packages. In most cases, however, the medical records administrator is not required to do any programming, although a basic understanding of the requirements and limitations of programming is necessary as is the knowledge of methods for controlling the accuracy and security of the data in computer systems.

Four-year colleges and universities offer bachelor's degree programs in medical record administration that are accredited by the American Medical Record Association and the American Medical Association. Required computer-related courses include: record management; health information management (which contains a word processing component); management technology (this includes systems analysis techniques and the development and application of quality assurance programs for health record sytems); and computers in health care (including evaluation of hardware and software components of computers for health information system applications, data representation and manipulation in computers, requirements and limitations of computer programming, controlling the accuracy and security of computerized data, design and cost effectiveness of systems, and record linkage and data sharing). Each of these courses also provides either a hands-on clinical experience or a simulated laboratory experience. Graduates of the program are expected to be proficient in all of these areas upon completion of their course work.

Social Scientists

Economists, sociologists, political scientists, anthropologists, and other social scientists, like other professional workers who write extensively, may use computers for word processing. In addition, they may use them for statistical analyses or to process statistical surveys. Standard software is available for routine statistical analysis, but some more unusual analysis and processing surveys usually require programming.

The computer-related training required for word processing or use of statistical software packages is usually a brief formal program followed by a period of learning while working. Many social scientists pick up the skills while in college, with or without formal training.

Those social scientists who process statistical surveys or do non-routine statistical analyses such as simulation of systems or the building and manipulation of models (e.g., economic models--equations which represent the ways in which economic variables interact with each other) require training in programming in FORTRAN or other high-level computer languages.

Urban and Regional Planners

Urban and regional planners use computers for calculations, office functions, research, analysis, and geographic data base management. They do statistical and other analyses, demographic and economic studies, modeling in land use or transportation planning or to solve such problems as where to build a hospital to serve population concentrations most efficiently. In their offices they may use computers for word processing, bookkeeping, and financial management. A computer can be used to store a data base of geographic information and use the graphics capability of the computer for mapping, analysis of land use, traffic flows, and other subjects. For many of these purposes a microcomputer is adequate, but large-scale data base work may require more storage capacity and a larger computer.

Software is available commercially for some of these uses, but some urban and regional planners find that they have to develop some of their own programs, either by learning programming or by employing a programmer.

University departments offering degrees in urban and regional planning generally provide one or more courses on computer use, including a computer methods course and courses in such subjects as statistics, mapping, geographic information systems, or modeling, in which the computer is used as a tool in analysis. By the end of graduate training the student has learned how to use computers for several purposes. Some students take an additional course in the computer science or another department at the university in order to learn programming in a high-level language such as FORTRAN.

Group III. Occupations That May Require Training in Operating Computers

Broadcast Technicians

In the electronic environment in which broadcast technicians work, much of the equipment has computerized controls, and in addition mainframe or smaller computers are used to monitor and program the sequence and timing of broadcasts. This means that understanding of computers, ability to operate them, and ability to maintain and repair them have to be added to the skills on electronic equipment required by these workers.

Broadcast technicians in small stations generally perform a variety of duties. In large stations they are more specialized, although job assignments may change from day to day and they have to have all the job skills. They may specialize in such jobs as transmitter operators, audio control, video control, recording, equipment maintenance, and field technical work (setting up equipment to pick up and broadcast an event outside the studio).

A network controls a whole day's log of programs, announcements, commercials, etc. for all its local stations on a mainframe computer. Local stations have some flexibility as to timing for part of the day's broadcasts so that local material can be inserted. The studio technician controls this on a smaller computer, using a keyboard.

There is no standard training program for broadcast technicians. High school courses in math and science provide a good background, and technical school, community college, or college training in engineering or electronics is good preparation for the field and helps in advancing to supervisory positions. Informal learning in electronics is another channel into the occupation. Four or five years' experience in some of the component skills such as lighting, camera work, audio or video control helps in getting a studio job. When new equipment is purchased, training of a week or so is given by manufacturers' representatives either on site or in the manufacturers' training facilities. In addition, technicians get updating training regularly, averaging a few days each per year. Maintenance technicians require more training when hired and get periods of training when new equipment is installed and about three times as much updating training (averaging 10-12 days) every year. In addition to their formal training, technicians spend a lot of time reading up on new equipment and new technical information.

Drafters

Drafters take rough sketches, specifications, and calculations made by engineers, architects, and designers, and turn out the detailed drawings to be followed by construction workers or factory workers in making a product. The drawings may show the views from several sides of the building or object to be made, and include specification for materials to be used and other information needed to carry out the job.

Many drafters now use computers with software programs for computer-aided design (CAD). Instead of sitting at a drafting table, they sit in front of the computer terminal and watch the drawing they are punching out on the keys appear on the computer's screen. This may increase their productivity or enable them to make better designs or provide more modifications to the design easily. Work most frequently done on CAD equipment includes electrical wiring, structural, and piping designs.

The training needed, in addition to the knowledge of traditional drafting skills they have gotten in their two-year training in technical institutes, community colleges, vocational or technical high schools, or through a three-four year apprenticeship, is specific training in using a CAD software program on a computer. Most trainees are drafters with several years of experience, but without previous computer training.

The training period may range from two days to three weeks; a common program is five days of training. Some of the initial training on new equipment is provided by the equipment manufacturers; some firms do their own training in-house. After the initial training it may take a CAD operator from two to as much as six months to develop a satisfactory level of skill. Firms have found it useful to conduct continuing training to advance their operators' skills (American Institute of Design and Drafting, CADD Committee, 1984; Schreiber, 1984).

Estimator-Analysts, Electric Utilities

Estimator-analysts make estimates and plan and schedule maintenance and repair work, including major overhauls of equipment such as turbine and generator units. Such units must be put back in service as quickly as possible, so the overhaul has to be carefully planned and scheduled. Estimator-analysts use a computer to schedule the work, following "critical path" methods. They track the work hours required for each phase of the job, the work orders issued, and associated costs. They also use computers for related purposes, such as keeping track of the stock of materials on hand.

Workers with maintenance shop experience are desired for these jobs. They are given training in estimating and planning maintenance work as well as critical path techniques. Training in use of the computer for overhaul planning is commonly given in one or two weeks. They then learn by working as estimator-analysts. They are provided with software user manuals and receive "on-line" help from the computer program. If they run into problems they cannot deal with they can get help from supervisors or specialists. By the time estimator-analysts have gone through one overhaul, planning and preparation cycle (five-six months), they usually have become proficient in the use of the computer in this work.

Health Technicians and Technologists

The Committee on Allied Health Education and Accreditation (CAHEA) accredits training programs for 23 allied health occupations, ranging from radiologic technologists who operate X-ray machines and include computerized axial tomographers, operators of the CAT scan, which gives cross-sectional pictures of different parts of the body by a narrow X-ray beam linked to a computer, through diagnostic medical sonographers who use equipment which produces an image from high frequency sound waves reflected from the body to examine internal organs, to perfusionists who operate the heart-lung machines used during coronary surgery. While the majority of these occupations involve the use of highly technical machinery, some of which are computer-controlled or computer-driven, the actual training programs for these occupations (ranging from six months to four years) include training in the operation of a specific piece of equipment rather than in the use of computers, although trainees would be likely to receive on-the-job exposure to the use of computers for recordkeeping and patient information storage while they are on clinical rotation during the training period.

No previous familiarity with computers is required of those entering training programs, although familiarity with word processing and information storage and retrieval functions may be helpful to trainees employed by hospitals or other health care facilities with computerized information systems. This would be particularly applicable to the occupation of medical assistant, as medical assistants perform a variety of administrative (as well as clinical) functions that are increasingly being computerized in physicians' offices, including: scheduling and receiving patients; obtaining basic patient data; maintaining medical records; handling correspondence and reports; purchasing and maintaining supplies and equipment; and assuming responsibility for insurance matters and office accounts.

Licensed Practical Nurses

Most licensed practical nurses receive no formal training in the use of computers during the course of their eight to twelve month training period. If their place of employment uses computers for record-keeping or monitoring of patients, practical nurses generally pick up the necessary skills on their own at the workplace, through self-study, or through continuing education courses, offered by professional organizations such as the National Federation of Licensed Practical Nurses.

Medical Record Technicians

The medical record technician serves as a specially trained, skilled technical assistant to the Medical Record Administrator, carrying out the many technical activities within increasingly computerized medical record departments. The medical record technician uses the computer to: technically analyze and evaluate health records according to standards; compile various types of administrative and health statistics for use in planning and evaluating; code symptoms, diseases, operations, procedures, and other therapies; develop reports on health information; and maintain and utilize a variety of computerized health record indexes and storage and retrieval systems.

In addition, the medical record technician operates word processing equipment, abstracts discharge data to support quality assurance activities, and supervises one or more health record service activities.

Most employers prefer to hire graduates of two-year associate degree programs accredited by the American Medical Record Association and the American Medical Association. Community and junior colleges offer over 80 such programs, which include 30-40 semester hours of technical courses. Curriculum requirements include courses in word processing, maintenance and acquisition of health data/information, and the use of computers in health care. These courses are supplemented by either hands-on clinical experience or simulated laboratory experience. Graduates of an accredited program may take a national accreditation examination to become an ART (Accredited Record Technician).

Pharmacists

The last decade has brought tremendous growth in the use of the computer in both hospital and community pharmacy practices. Computerized patient profile systems keep detailed records of patient compliance (e.g., whether patient prescriptions are being refilled in accord with physician orders), monitor potential drug interactions (some machines sound a beeping alarm if two incompatible drugs turn up in one patient's file), and aid in the calculation of dosages. Pharmacists also employ computers for overall practice management and inventory control. The degree of computerization ranges from 100 percent of functions to the limited use of personal computers and commercially available software.

Training in the use of the computer is now incorporated into the curricula of all colleges of pharmacy, either through hands-on experience in simulated laboratories, use of computers in conducting required library research, or in externships and clerkships in hospital or community practice sites. All graduates of colleges of pharmacy are required to have knowledge of computer applications in pharmacy practice as part of their training. Elective courses (consisting of a mix of classroom learning and hands-on experience) may offer a programming language and in-depth knowledge of systems design.

For pharmacists already in practice, professional associations, such as the National Society of Pharmacists, offer brief, continuing education seminars and workshops on computer systems, including hands-on experience, evaluation of hardware and software, data file management, development of patient profile systems, drug interaction systems, and related management systems. In addition, when computerized systems are introduced into or updated by a hospital pharmacy, the equipment manufacturer provides employees with two to three days of hands-on training in the use of the system for dispensing drugs and keeping patient records.

Physicians

While computer-based medical education activities are beginning to expand, currently there is little use of computers in required medical courses, with the exception of some computer-assisted instruction and evaluation and a few programs that draw on the computer's ability to model dynamic systems for simulations. Some medical educators appear reluctant to use computers out of concern that the basic medical sciences will be de-emphasized; others simply lack the necessary expertise to introduce computer-based medical education.

Medical schools are, however, increasingly offering electives that relate to the use of computers in response to student demand for such courses. These electives are likely to be in the following areas, particularly in the first: 1) diagnostic consultation systems - computer-assisted diagnosis; 2) automated medical records; 3) hospital information systems, the most innovative of which consist of a comprehensive data base containing medical, financial, and biographic information; and 4) personal information management systems, which consist of a) an internal personal data file which assists financial management of the practice and includes patient records and the physician's "accumulated memory" of experience and literature extracts, b) access to data systems, e.g., on-line journals, laboratories, patient monitoring systems, and specific data systems, c) internal manipulative and analytic capabilities, encompassing computation of stored data, report development, and comparison of stored data with external data, d) access to decision support systems, and e) network capability, e.g., tele-conferencing and electronic mail and bulletin boards. In many cases, students are creating and developing their own computer-based teaching programs.

Nearly 20 percent of all medical offices have computers but they are used mainly for record-keeping, insurance, and billing by other office staff. The percentage and usage are expected to increase substantially over the next five years as the computer's ability to pull together large amounts of information for analysis keeps on growing.

Registered Nurses

As the use of computers becomes more prevalent in health care settings, registered nurses are increasingly being required to access computers for a variety of purposes. Currently, the most prevalent use is for inputting, storing, and retrieving information on patient admissions, discharges, and billing. Increasingly, patient chart information and care plans are being computerized, with terminals located at nurses' stations. Some of the most advanced health care institutions are also beginning to use computers for such traditional nursing functions as the monitoring of patients and administration of intravenous fluids.

Until very recently, training in the use of the computer for registered nurses has been through clinical experience (e.g., actually working in a hospital with computers) during the course of a two, three, or four year nurses' training program, or through brief, hands-on training when the equipment is introduced into the health care facility where the nurse is already employed.

Currently, registered nurse training programs (particularly, the three and four year programs) are beginning to introduce training in the use of computers into the curriculum. This is especially true for programs that are affiliated with hospitals that are committed to rapid computerization. Some nursing programs recommend that their students take an introductory course in computer science as an elective, while others incorporate into existing courses a component on the use of the computer which includes basic knowledge of how the computer works, how to access the computer, store and retrieve information, and how to get off the computer.

Some nursing programs require that students take courses that provide computer-aided instruction. In these courses, the instructor provides instruction in how to access the computer, and the student becomes familiar with its operation through hands-on experience.

It is likely that within the next five years, most registered nursing programs will require that their graduates be familiar with the use of computers in health care settings. While no previous knowledge of computers is currently necessary to enter a registered nurse training program, familiarity with computers (e.g., from an introductory, high school class) is viewed as a distinct advantage for the student.

Air Traffic Controllers

When an airline pilot files a flight plan it is recorded on a computer in the Federal Aviation Administration (FAA) traffic control system, and the subsequent progress of the flight or any deviations from the plan are entered into the computer so it has a running record of the flight. When an air traffic controller approves a change in plans he or she enters it into the computer.

Air traffic controllers are required by law to go through a rigorous training program, including three and a half months at the FAA Academy in Oklahoma City, followed by one of three programs for different parts of the system. For work in Air Route Traffic Control Centers and Airport Traffic Control Towers, 20-1/2 additional months of training are required; for flight service station jobs the additional training period is a maximum of 1040 hours. Only a small part of total training time is devoted to learning how to use the computer. Since more than one type of computer is in use in the air traffic control system, controllers may have to spend additional time to learn a system different from the one they trained on if they switch to working in another location. The relatively long training time is necessitated by the requirement that the controller be fluent in using the computer before beginning work.

A new air traffic control computer system is under development to supplant the present system, and new training programs in its various phases will be developed as the new system is put into effect.

Airplane Pilots

Some of the most advanced models of commercial aircraft are equipped with flight management computers. While still on the ground, the pilot puts the flight plan into the computer, using the keyboard. In flight, the computer continually reports on the aircraft's performance (speed, temperature, fuel consumption and supply, altitude, etc.) and provides navigation information, such as the facilities and navigational aids en route and radio frequencies on which nagivation information is broadcast. The automatic pilot works from the information that has been stored in the computer. The pilot can use the computer while it is working on all this to simulate changing the route and estimate the effect of this on fuel consumption, arrival time, and other variables. No programming is needed.

Pilots, who are already highly qualified when they are assigned to training for these new aircraft, go through a training program of several weeks. At first they get classroom training, some of it on the skills needed to use the computer. Then they work with a flight simulator in which they learn to react to signals from the equipment in "real time." After completion of the training program they operate the aircraft under supervision until the supervisory pilot is satisfied that they are fully competent. The training is paid for by the airline.

Commercial and Graphic Artists and Designers

Moving graphics, such as are used in television broadcasts on the weather, or television and motion picture captions, can be produced on specially-designed computer-based equipment. The graphic artist using the equipment enters instructions with a keyboard or a stylus, and drawings or photographs may be entered with an electronic scanner. The computer is programmed to convert these instructions into an animation, in colors, on the computer screen and on tape from which it can be reproduced. Non-moving designs may also be produced on the equipment.

The graphic artist doing this work, in addition to training as an artist, needs a few days to a week of initial instruction provided by the manufacturer of the equipment, and then learns by practice, with the assistance of a manual and an occasional telephone consultation; subsequent brief periods of training are usually helpful. In some television studios a broadcast technician is given this training instead of an artist. Time required to learn to produce graphics efficiently may take several months, depending on the individual and the complexity of the design.

Industrial Designers

Industrial designers use computer-assisted design (CAD) to document their designs, i.e., to translate the initial sketches they have made into precise drawings, usually from various angles, with accompanying dimensions and specifications, that can be used by machinists, tool and die makers, or other craft workers to manufacture the product, or can be fed into numerically-controlled machine tools. The design can be modified with the CAD system. The CAD equipment may be operated by a designer or by a technician in the designer's office.

Several weeks to one month of formal training in operating the CAD system using a computer keyboard is required. The new trainee then begins using the system and in about six months of steady work is usually proficient enough to realize productivity gains over manual drafting. Programming is not required, but some CAD software systems permit the operator to add special applications or short-cuts by using a high-level programming language that is learned relatively easily. The designer using this equipment still needs skills in free-hand and engineering drawing as well as model building.

Lawyers

Law firms today are using computers mainly for word processing, timekeeping, and billing. Particularly for those attorneys practicing in the fields of taxes, estate planning, real estate, bankruptcy, and patent law, the personal computer represents an important tool in the delivery of legal services.

While in law school, almost every student receives some exposure to the use of computerized data bases (such as Lexis, Dialog, and Westlaw), either through a course in legal bibliography or through the use of the data base in the school's law library. These data bases contain references to cases that embody precedents in a variety of legal areas, constituting the bulk of legal research. Some law schools, currently only a small number, require that all their students receive training in the use of personal computers through specialized computer education courses, while other schools expect their students to pick up the necessary skills mainly on their own.

In regard to the current use of computers within law firms, corporate legal departments, and government agencies, recent studies have found that large firms with 50 or more lawyers and small firms with fewer than 15 lawyers are most likely to own and use computers. Despite the belief, expressed by an overwhelming majority of lawyers, that in the next five to ten years computers will be important, perhaps crucial, to the delivery of legal services, in actuality the number of lawyers currently using computers themselves appears to be very small (*Lawyer Hiring & Training Report*, July 1984). Most law firms have yet to make formal commitments to integrate the use of computers into their practices. This may be due, in part, to most lawyers' inability to type as well as the lack of software that has been available for legal services (although this situation appears to be changing rapidly).

In addition, many attorneys do not appear to understand the potential of personal computers and do not want to commit the time necessary to learn. As more software packages come on line, however, and as familiarity with computers becomes more prevalent with the entry of recent law school graduates into the marketplace, law firms may be compelled to require that their lawyers learn the benefits and uses of personal computers in the delivery of legal services. As the title of a recent seminar offered lawyers by a major management consulting firm puts it "An Executive Briefing: Computers - Can You Afford Not to Understand?"

Legal Assistants

Often referred to as paralegals or legal technicians, legal assistants perform a variety of duties directly under the supervision of a lawyer. These may include: legal and factual research; interviewing clients and witnesses; receiving and organizing material for cases; preparing estate tax returns, material for probate, and simple wills; and monitoring legislation and federal regulations. Familiarity with the operation and applications of computers in the majority of these task areas, particularly in the preparation of materials by word processing and in legal research, is increasingly important.

Although in some cases, lawyers will train already experienced legal personnel, such as legal secretaries, for legal assistant positions, more and more employers are requiring formal training for these positions. Several hundred programs are offered by a variety of providers: law schools; colleges and universities; proprietary schools; legal assistant associations; and several large law firms. While most legal assistant programs take two years to complete, they range from an intensive, full-time summer program to as long as four years. Depending on the particular program, graduates may receive a certificate, an associate degree, or a bachelor's degree.

Currently, most paralegal training programs do not require that graduates complete a computer-related course, although such courses as "Introduction to Microcomputers" or "Computer Application and the Law" are frequently offered as electives. As employers increasingly seek to hire paralegals with computer training or experience, it is very likely that more and more training programs will require that graduates take at least one course dealing with the use of computers, word processing, and litigation and information management.

In addition, some law firms are sending one or more of their legal assistants to day-long workshops, offered by schools and other outside providers, to be trained in the use of computers. These paralegals will then frequently train other paralegals in the firm in the operation and application of the computer in their office.

Librarians

By 1990, it is projected that the majority of medium-sized and large libraries in North America will be automated, with smaller libraries following suit by the year 2,000. Currently, there are about 100,000 libraries in the United States employing 150,000 professional librarians, with a growing number of information professionals working in business and industry in jobs managing information storage and retrieval. New technologies affecting the field of library and information service include computers, microcomputers, word processors, mass storage devices, fiber optics, and videodiscs. Online terminals for accessing information networks have been one of the most significant advances in library technology of the last decade, and computer output microfiche (COM) is becoming a common medium of information in libraries. Libraries will continue to have large collections of printed materials, but a significant percentage of statistical and directory data will be accessed through computer terminals, as will almost all bibliographic data.

A master's degree in library science (M.L.S.) is needed to obtain an entry level professional position in most libraries, with most employers preferring graduates from the 70 programs accredited by the American Library Association. Computer technology has become an integrated part of the one-year program offered by these schools. Almost all teach one or more courses on information storage and retrieval, while nearly 75 percent teach courses in library automation, systems analysis, and interactive computer systems. Online bibliographic citation systems have become so important that instruction in these systems is widely viewed as essential. Schools do vary, however, as to whether such courses are offered as part of their core curriculum or as an elective and in regard to whether such courses are theoretical introductions to library automation or more practical, hands-on experiences.

Microcomputer technology continues to shape the pattern of library automation development, and with the introduction of new systems, continuing education is necessary. Typically, the vendor of the equipment provides training, either on the job or through short, hands-on courses offered at centralized facilities.

Library Technicians

Also known as library technical assistants, library technicians perform the majority of support activities involved in operating a library. Increasingly, these activities include retrieving cataloging information from computer data bases and using automated equipment to track circulation, acquisition, and serials activities.

Although some libraries, particularly smaller ones, are willing to train on the job high school graduates with no previous computer-related experience, the majority of libraries are looking for technicians with computer experience or training. Graduates of two-year college associate of arts programs in library technology are considered most desirable. Many of these programs now include at least one required course on library automation, designed to give the technician a basic understanding of the roles and uses of the computer. Because there are so many different automated systems used in libraries (for example, there are over 150 circulation systems), courses focus on a general familiarity with library automation, with training on specific equipment provided by the library where the technician is employed.

Specific on-the-job training may take a variety of forms. When a library purchases computerized equipment (such as an on-line data base system), vendor-provided training is built into the purchase price. Generally, a two-week training course is provided at the library by the vendor, with at least 50 percent of the time spent using the equipment. Two to three months of constant application and use of the equipment are usually required to achieve proficiency on this equipment, as many problems that are not confronted within the training period are likely to arise initially.

Training and proficiency in the use of automated circulation systems usually take less time, although there is considerable variation, depending on the individual's "attitude" toward the equipment.

Periodic staff development training workshops relating to the use of computerized equipment are offered by many libraries in-house as well as by equipment vendors, private training companies, and professional associations such as the Council on Library Technicians. A common practice is for a library to send to an outside workshop one staff member who then trains other staff in-house.

Purchasing Agents and Managers

The officials who buy the materials used by companies in their work - raw materials, components, machinery, office equipment, and supplies - can use computers for several purposes. They can keep technical information and specifications on the products they buy, evaluations of vendors, and transportation and price information. They can also use computers to keep current records of activities: purchases; deliveries; payments; and inventory in order to know when to buy more.

Although there are generic software systems for purchasing, companies generally need to develop their own systems and software, since the purchasing records have to fit into the entire information system of the firm. Purchasing agents work with systems analysts to tell them what they need, and the system and software are developed by the systems analysts and applications programmers. The computer used is likely to be a mainframe or minicomputer, with access through terminals at various places within the company, including the purchasing agent's office.

The National Association for Purchasing Management sponsors educational seminars to assist purchasing agents in determining the information needs of purchasing departments and how they can be met. After such seminars the purchasing managers can communicate to computer systems analysts the specifics of their problems and needs. Once the computer system is developed the purchasing agents or managers learn to use the terminals in their offices with minimal instruction.

Reporters and Correspondents

Reporters and correspondents are most likely to use a computer for word processing in the preparation of stories for newspapers, news magazines, radio, or television. There are no requirements for computer skills, and little formal training is offered. Most reporters pick up the necessary proficiency through hands-on experience.

Technical Writers

Technical writers write about scientific and technical developments, primarily for "insiders" who are involved in scientific operations. A technical writer gathers, sifts, condenses, and presents in understandable form the large amount of detailed and often difficult data required for reports, scientific journals, instruction manuals for technicians, equipment specializations, contract proposals, and other documents.

Chief employers of technical writers include professional societies, scientific and medical publishers, manufacturers, universities, foundations, federal agencies, and other organizations with research programs.

Educational requirements for technical writing are a bachelor's degree with combined training in both writing skills and a specialized field such as engineering, business, or one of the sciences. Although master's degree programs in technical writing are available, relatively few technical writers enter this field directly from college. The majority work initially in other areas, such as technicians, scientists, or engineers, then gradually assume writing responsibilities. Familiarity with computers is increasingly desirable as the use of computers and computer-based equipment becomes more prevalent in scientific and technical fields.

The required ability to use a computer is similar to that required of reporters and correspondents - being able to access information and a word processing program.

Writers and Editors

With the exception of technical writers (see separate description), there are no computer training requirements for becoming either a writer or an editor. The accepted practice when computer terminals are introduced into a newspaper office, for example, is for everyone using the equipment to be given a very brief word processing training (several hours' duration) at the worksite and then learn by doing. Within a few weeks, most writers are considered reasonably proficient, even if they are only using two fingers on the keyboard.

Most journalism schools use terminals but do not provide courses in their use. Students are expected to pick up the needed skills through hands-on experience.

Managers and Administrators

Virtually every type of industrial plant, commercial enterprise, and government agency employs managers and administrators whose job is to achieve the objectives of their organization by planning and directing the activities of other employees. Many become managers by promotion from clerical, sales, professional, technical, or craft jobs. They are generally required to have the basic skills within their specific area (e.g., marketing, accounting, real estate, finance), and, depending on the size and degree of computerization within their specific organization, may need to use computers with commercially available software to store and retrieve information about business operations or to do calculations or spreadsheets. In general, if any training is required, it is given on the job, with no previous computer education or experience required. This is true for such diverse occupations as construction project managers, hotel managers, and fast food restaurant managers. In each of these areas, basic managerial skill and thorough knowledge of the business or trade are still the preferred prerequisites for moving into managerial positions.

Increasingly, companies are hiring graduates of management courses at college and those with a master's degree, particularly a master's in business administration, for management trainee positions. Currently, many business schools are in the process of revising their curricula to require courses such as an introduction to computing which may include the use of personal computers, word processing programs, spreadsheet analysis, and graphical display of information. Some courses also include how to design, write, and edit programs, so that the manager will be able to develop specialized programs to fill gaps where existing software does not meet the needs of the organization.

In addition, business schools increasingly expect students to use the computer as a tool in many other courses, such as: the analysis and operation of inventory systems; electronic data processing systems; macroeconomics--forecasting and policy; management of information systems; and marketing research and planning. Training in the use of the computer in these areas is particularly important to financial managers, hospital administrators, and middle managers who direct various departments and particular areas, such as personnel, accounting, finance, or marketing.

Real Estate Agents and Brokers

Currently, more than 55 percent of the 115,000 residential real estate firms in the United States are computerized. The majority of those firms that do have computers have "dumb terminals" that are used to access, through a modem, a mainframe computer's automated multiple listing service for their particular geographic area. The agent calls up the listing, views it on the screen, and prints out the listing(s) of interest.

When a new employee is hired, one of the experienced agents trains the new person in how to access the multiple listing service. This takes no more than a few hours, and no previous experience on computers is necessary.

Increasing numbers of real estate agents are purchasing personal computers on their own and are getting trained by the computer vendor, outside trainers or schools, or through self-study. Software packages aimed at the real estate broker, such as calling up and figuring mortgage and interest rates in terms of monthly payments, conducting searches of recent sales of houses, computing closing costs, and filling out forms and documents, are becoming available for use on personal computers.

Sales Representatives, Computer or Software Manufacturing

The people who sell computers and related equipment, including software, have to have technical and marketing knowledge as well as sales skills.

Many sales personnel enter the field directly from college; a few come with experience in sales, engineering, or other technical occupations, and others come with experience in an industry or occupation in which there is a potential market for computer applications.

They get basic training in computer concepts and marketing, and learn how to operate minicomputers and how to design computer installations for various purposes. The sales representatives for some computer companies specialize in selling either large or small systems, and some specialize in selling to certain industries, such as manufacturing, finance, retail trade, or utilities.

To keep up with a rapidly changing technology, they have to take brief courses from time to time in new equipment, marketing, and in the equipment sold by competing firms.

Securities Sales Agents

Securities sales agents have computer terminals on their desks, which they may use to get current prices or other information on individual stocks, bonds and commodities, general market information, or the status of customers' accounts. The computer is used for information retrieval only; the information is put into the computer's memory by workers in the company's main office.

Training required is very brief: a few minutes of instruction may be given in using the keyboard to query the system's memory, or the new worker may learn how to do it from a small manual. This may be part of an extensive training program given to new sales agents to enable them to meet licensing requirements; the trainees pick up the limited skill in using the computer in the course of the training program.

Travel Agents

Almost 85 percent of travel agencies use computer equipment leased from one of the major airlines. Travel agents use this equipment for data retrieval and storage to help them determine and keep track of modes of transportation, travel dates, costs, and accommodations in planning individual and group travel.

While it is not required that entrants into this occupation have training on computers, larger travel agencies in particular consider previous computer-related training or experience as very helpful, especially experience as an airline reservation clerk, since much of the work is similar.

In regard to the training of new employees, each travel agency receives a certain number of training slots from the airline whose equipment it is leasing. The airline pays training, travel, and per diem costs for the agency to send its employees to a central training facility, where they participate in a four-week training program, with two weeks devoted to the use of the computerized equipment. Larger travel agencies have a policy that all their new employees must be trained through the airline program. If the agency exceeds its alloted number of trainees, it pays the airlines for the cost of training and provides travel and per diem for the employee. Smaller agencies, on tighter budgets, are more likely to train additional employees themselves through on-the-job training.

While the travel agent is considered functional in the use of the computerized equipment upon completion of the four-week airline training program, it may take up to six months of experience for the agent to become totally proficient on the system.

Airline Reservation Agents

Airline reservation agents work in large central (home) offices, answering customer telephone inquiries and booking reservations. Each agent uses a computer terminal to obtain information on schedules and to reserve space for passengers.

Although previous travel-related experience with computerized equipment is helpful, it is not required, as all new airline reservation agents, regardless of past experience, must go through the initial training program.

Trainees are sent to a central training facility, where they receive three weeks of classroom instruction, with about 75 percent of the time devoted to understanding and using the computer. The fourth week of training is given back in the home office, with 20 hours devoted to using the computer on the job and 20 hours spent in the classroom dealing with any problems or deficiencies. In the fifth week, trainees are put on a regular work schedule.

During the first three weeks of training, employees are not on the payroll but the airline provides travel, room, and board. At the beginning of the fourth week, employees start working on a regular salaried basis.

All airline reservation agents receive one hour a month of continuation training. Approximately four or five of these hours over the course of a year are related to the use of the computer.

Bank Tellers

In the course of receiving and paying out money and keeping records of various financial transactions, the majority of bank tellers use computers mainly for storage and retrieval of information from individual and corporate accounts and in some cases for calculating, although separate calculating machines are still in frequent use alongside the computer.

No previous computer experience or training is required, as each bank provides its own training to new tellers. This training, which includes hands-on experience with the computer, may last from several days to four weeks. It may be provided at the worksite or at a centralized training location maintained by the bank. Many of the training programs use computer-aided instruction in which the trainees receive almost all their training through interaction with the terminal, aided by a supervisor. Simulated transactions enable the trainee to gain hands-on experience prior to beginning work.

Tellers are expected to be proficient in the use of the computer by the end of the training period, although speed increases with several weeks on the job.

Bookkeepers and Accounting Clerks

Increasingly, businesses are using computers to keep systematic and up-to-date records of accounts and business transactions. Bookkeepers and accounting clerks enter information on accounts receivable and accounts payable into the computer as well as review computer printouts for accuracy and completeness. They prepare financial statements, calculate payrolls, record business transactions, and compute interest, rental, and freight charges, using commercially available software. Bookkeepers and accounting clerks also perform word processing tasks, such as preparing vouchers, invoices, and other financial records. They usually input their own data and use a ten key adding machine in checking data.

Employers with computerized equipment prefer hiring employees with previous experience or training in data processing and use of computers. Depending on the size and complexity of the employer's organization, high school courses in principles of accounting together with some hands-on experience in computer operation may be sufficient to qualify for entry-level positions. Additional brief training in the specific hardware and software used by the employer is provided on the job, under the direction of an experienced bookkeeper or an accountant, and is usually mastered within several weeks.

Other sources of training are programs offered in two-year colleges and proprietary business schools that range from six months to two years. The two-year A.A. degree in accounting offered by community and junior colleges is designed to prepare students for positions as bookkeepers. In addition to accounting courses, students are required to complete courses in automatic data processing and, in some programs, must take an introductory course in programming. Completion of the A.A. program is considered very desirable by employers and may enable the degree holder to enter the business in a higher than entry-level position.

Cashiers

Working as a cashier - receiving money, making change, filling out charge forms, and giving receipts - is generally an entry-level position that requires little or no previous experience or training, as most employers provide their own training. A rapidly growing number of cashier jobs, particularly in department stores and supermarkets, involve the operation of electronic cash registers, computerized point-of-sale registers, or computerized scanning systems. Depending on its complexity, a computerized system, such as that often found in a large grocery store, may automatically calculate taxes and change due as well as record inventory numbers and other information.

In a small business, the beginner is usually trained on the job by an experienced worker (this is known as the "buddy system"). After a few hours or a day of hands-on experience, the new cashier is ready to work alone. In large organizations, which are more likely to have computerized registers or scanners, a more formal training course, consisting of classroom instruction and hands-on experience, is likely to be offered. Within supermarkets and grocery stores, which employ the largest number of cashiers, training averages about two days, with at least one day spent learning on the register. Larger grocery chains may provide two days of classroom instruction, with much of that time spent viewing films and memorizing product codes, followed by a third day of in-store training on the register, with regular work beginning on the fourth day.

Some companies receive training materials free on loan from the equipment manufacturer, while others purchase training programs from private retail training vendors who offer a variety of materials ranging from 45-minute videotape "seminars" that can be used for beginners or as a refresher course to self-administered audiovisual/workbook combination programs that cover all aspects of a variety of computerized systems and take the trainee from four to six hours to complete.

While proficiency on simple cash registers may take only a few days, the complexity of many of the computerized systems sometimes dictates a period of up to four months before new operators become expert in their use.

Computer and Peripheral Equipment Operators

Operators work on large computers and associated peripheral equipment. Following the instructions written by programmers, they load the tapes or disks containing the program onto the computer and also load on the tapes or disks containing the data to be processed. They watch the console while the computer is running, to check for malfunctioning, and correct any problems that arise. Peripheral equipment operators do the same for printers and data storage units.

Training for operator jobs is given in technical institutes, community colleges, secondary-level vocational schools, and business schools; only one-third of the operators were trained in schools (Appendix Table A-8). A few learn the work while in military service. One major computer manufacturer provides an eight-day training program for entry-level operators; another manufacturer has a four-day program. Supervised experience after these short programs is necessary. Nearly half the operators reported having had informal on-the-job training. Since models of computers and peripheral equipment differ, some on-the-job training is always needed, from a few weeks for peripheral equipment operators to several months for computer operators. From time to time operators need to learn about new equipment or methods, which they can do by self-study or taking short courses.

Data Entry Keyers

Once called "keypunch operators" because they used a small machine to punch holes at the appropriate places in cards which were used to feed data into the computer, data entry keyers may now enter the information on magnetic tapes.

The training required is brief, given in several days. For many jobs typing ability is required. A third of the keyers had some training in schools - most commonly in secondary school vocational courses; more than half got training from their employers (Appendix Table A-8).

This is one computer occupation for which demand is declining, because of attempts to eliminate or reduce the labor cost required in data entry, as well as the potential for error that creeps in wherever people are involved. In large data systems data entry is done directly by computer terminals at the site of each transaction (the check-out counter in a supermarket, sales counter in a store, charge desk in a library, etc.). In others, such as large statistical operations, optical scanning is used to get the information into a record the computer can read.

Directory Assistance Operators

Directory assistance operators use computer terminals to look up and provide telephone numbers. No previous computer (or typing) skills or experience are required. All new workers receive five to seven days of training at a centralized training facility operated by the employer. Training consists of a self-paced course in which the trainee, using a learning guide, sits at the terminal and takes live calls, under the supervision of an instructor (there is one instructor for every two trainees). The trainee learns how to key in the necessary codes to make searches for business, resident, and government listings. By the end of the training period, operators are expected to have an accuracy rate of 80-85 percent, compared to 95 percent accuracy for experienced operators. New operators are monitored by their supervisors during the two to three months following their initial training to determine their proficiency and to provide any additional training that may be necessary.

Postal Clerks: Letter-Sorting Machine Operators

In large post offices and mail processing facilities, much of the sorting of letter-size mail is done by postal clerks "keying" the ZIP code of the letter passing before them. Letters are sorted to an appropriate "bin" on the back of the letter sorting machine from which they are pulled and bundled or sacked for the destination office.

All training for operators is provided on the job by the U.S. Postal Service. No previous experience with computerized equipment is necessary.

Each trainee is provided an orientation to the computerized training system (which is a simulation of the actual letter sorting machine) as well as the unique keyboard, consisting of two rows of 10 keys, each numbered from zero to 9. Trainees are allotted 47 hours to train for their first assignment and 32 hours for a subsequent assignment. Successful completion of training is accomplished by keying at the criterion speed for the assignment at an accuracy of 98%.

During the first 45 days after qualification, the employee is monitored by his/her supervisor on the letter sorting machine to assure proficiency and to determine any keying problem areas. Employees must complete a 90-day probationary period. After the probationary period, employees are continually monitored to assure at least 95% accuracy.

Secretaries

With the introduction of personal computers and such services as electronic mail, the technical skills required of secretaries are shifting from shorthand and typewriting skills and the operation of basic office equipment to such areas as: knowledge of data/word processing; proficiency in operation of personal computers including the use of spreadsheets, data base management, and graphics software; telecommunications including facsimile and electronic mail; and the integration of graphics with other software packages.

According to the 1985 Newspaper Help Wanted Advertisements Survey, sponsored by the Professional Secretaries International Research and Educational Foundation, 30.3 percent of secretarial ads required word processing/computer skills or the desire to learn them, while virtually all of the ads indicated that typing would be required on the job. Employers are still very much concerned that secretaries have a solid foundation in the more traditional secretarial skills but are increasingly looking to hire secretaries with experience in automated office equipment.

In an automated office, it becomes the secretary's responsibility to revise and maintain data in spreadsheets as directed by the employer. The secretary also needs an understanding of data base management software, since keeping records up to date as well as adding new records are largely the secretary's task. In addition, the employer may direct the secretary to produce reports using the information in the data base. Secretaries may also be called upon to clean up, proofread, and format correspondence and reports created by the employer in draft format.

Training for secretaries in the use of automated office equipment is increasingly available from a wide variety of sources. For those not already employed as secretaries, training is available from high schools, proprietary schools, two-year colleges, storefront schools, community organizations, and self-study courses. High school vocational education programs focus mainly on general office skills, shorthand, and typing, with only a small number of programs offering hands-on experience with word processors or personal computers. Proprietary schools and two-year colleges offer one- to two-year programs in secretarial science, with approximately one-quarter of course time devoted to use of computerized office equipment. Tuition for a typical ten-month secretarial course at a proprietary school averages $2,000, compared with average annual tuition costs of $500 at public two-year colleges. Storefront schools (operated by private training companies) offer a variety of courses, typically ranging from one to three days, in the use of different computerized equipment and software, with more than 50 percent of the training spent in hands-on experience. These courses may range in cost from $100 to $300 per day, depending on the level and sophistication of training provided. Course completers are generally expected to feel comfortable using the system upon finishing the training, with proficiency attainment varying depending on both the complexity of the system and the individual's adaptation to its use, on average taking between six to eight weeks for word processing, for example.

For secretaries who are already experienced or employed, the majority of training on automated equipment is provided on the job. New employees with previous experience on computerized equipment are usually given brief on-the-job training by a supervisor, combined with self-study and the use of a manual. When personal computers or word processors are purchased by the employer and introduced into the workplace, the equipment manufacturer usually provides a free, brief two- to four-day training program to an agreed-upon number of employees, either in the office or at a centralized training center operated by the manufacturer. (Such training programs are also offered for a fee by private training companies, who may offer customized programs tailored to the employer's particular need.)

Once training has been completed, employees usually have access by telephone to a support center maintained by the manufacturer. Some large employers operate in-house information centers, designed to provide immediate trouble-shooting assistance with both hardware and software. Here again, the time required to become proficient varies considerably, depending on the equipment and the individual, as well as the amount of time actually spent using the equipment. By the end of two to three months, most secretaries are able to use the computer or word processor comfortably and efficiently.

Stenographers and Shorthand Reporters

In general, the qualifications and training required for stenographers do not include use of the computer. Employers are usually most concerned that stenographers have speed and proficiency in whatever shorthand methods they use.

The exception within this occupation is the shorthand reporter, a specialized stenographer who records all the statements made in a proceeding and is most frequently employed as a court or conference reporter. A growing number of these reporters are using Computer Aided Transcription (CAT), a system in which a computer directly translates the reporter's shorthand notes into English, greatly reducing the time it takes to produce a transcript. The reporter makes a verbatim record of the proceedings (using a stenotype machine), feeds the information into a computer, then edits (or "scopes") the transcript on the video display terminal (although in some cases the transcript is edited by a scopist and not by the reporter). The computer then prints out a complete transcript of the proceedings.

While the process of becoming a shorthand reporter is initially similar to that of a stenographer—the student must still learn shorthand and how to use a stenograph machine--the use of the computer has led to changes in curricula. Of the more than 400 postsecondary schools and colleges offering two-year training programs in court reporting, seventy programs have been approved by the National Shorthand Reporters Association. All of these programs either provide training geared to the use of computers or have ordered the equipment to provide such training. While these programs still teach basic shorthand theory, they teach a form and writing style that are compatible with the computer, and then switch the student to using the computer once the theory has been mastered. The student learns how to make a "personal dictionary" for the computer, which stores the individual's own particular shorthand outlines and what they stand for, as well as how to compile a "job dictionary" which contains the reporter's shorthand symbols for words and names related only to a particular case or job. The reporter must be able to attain a minimum speed of 225 words per minute (wpm) to be considered minimally competent (compared to speeds of 120-150 wpm for a stenographer).

There are currently on the market seven different major Computer Aided Transcription systems, and the skills learned on one system are generally transferable to the others. The equipment manufacturers also provide the necessary software and brief training in the use of their systems. The equipment (and accompanying training) may be owned and financed by the reporter (60% of shorthand reporters are free-lancers), leased by the reporter from an employer, or owned by the employer (e.g., a court) and used by the reporter, with all costs assumed by the employer.

For those already in the field, continuing education programs, such as those required by the National Shorthand Reporters Association for certification as a Registered Professional Reporter, include one-day sessions on writing for the computer and management through the computer. Proficiency in the use of CAT depends on how compatible the reporter's writing style and basic theory are with the computer. If compatibility levels are high, proficiency can be attained in as little as a few weeks. If the basic theory was learned long ago and the reporter's writing style is not very "clean," reaching maximum proficiency can take up to a year.

Traffic, Shipping, and Receiving Clerks

The primary duty of traffic, shipping, and receiving clerks is to verify and keep records on incoming and outgoing shipments. Companies employing these clerks are increasingly installing computerized equipment to assist with inventory control and record-keeping. These clerical positions are generally entry-level jobs, requiring no previous experience in the use of computers.

Each company provides hands-on training on the job for the new employee or when the new equipment is introduced into the workplace. Most of the training generally consists of several hours learning how to scan labels and product codes, using a wand connected to a hand-held data processing unit or learning how to enter a manifest number on a keyboard and viewing the order on a monitor, rather than using pencil and paper. Training in the use of the computerized equipment usually takes about the same amount of time as teaching the old, manual system, and proficiency is generally achieved within a few days.

Typists and Word Processing Machine Operators

While many employers are still looking for typists with fast and accurate touch typing skills, a growing number of employers are also requiring word processing skills or experience when hiring typists, as more and more businesses are purchasing personal or minicomputers for their offices. Word processing machine operators and typists using word processing software on computers record, edit, store, and revise correspondence, reports, statistical tables, forms, and other materials. They also may operate equipment that extends word processing capabilities such as single or multiple printers or optical character readers.

The majority of word processing training is provided on the job. In many cases, it is learned through hands-on self-study, using a manual and the instructional material that is part of most word processing software. Manufacturers of personal computers and word processors provide free, brief (two- to four-day) training programs to employees of their customers. The training is offered either at the workplace or in a centralized training facility operated by the equipment manufacturer. Upon completion of the training, an average of six to eight weeks of hands-on experience is required for the worker to become proficient. If problems arise, the worker can call either an in-house information center for assistance or the manufacturer's support center. If this doesn't solve the problem, the manufacturer may send a market support analyst or systems analyst to the customer's office for a one- to two-day consultation.

Employers may also provide their employees with customized word processing training through private training vendors, some of which specialize in providing training geared to the equipment of a large manufacturer (e.g., Wang or IBM). These vendors typically offer brief, two- to three-day training mainly at the worksite but also at their own facilities.

There are a wide variety of word processing training programs available to persons who do not have the option of on-the-job training open to them. These include: high school courses in the use of personal computers for word processing; programs at two-year colleges offering courses such as introduction to word processing and word processing applications; and private proprietary schools with word processing certificate and diploma programs. A typical word processing machine operator's training program, taken from a secretarial school, consists of a twelve-week program, with two hours of each eight-hour day spent in hands-on learning. Students are expected to be proficient at the end of the program.

Word processing training programs are also offered, at low cost, through local governments, community organizations, and public schools. Programs funded through the federal government are offered at no cost to disadvantaged target groups through local organizations such as the Urban League and Opportunities Industrialization Centers.

Other Clerical Occupations

There is a large number of administrative support occupations in which workers: prepare and keep records; arrange schedules; collect, distribute, or keep track of money, material, mail, or messages, or perform other similar administrative support functions. Virtually all of these jobs are entry-level positions and require no previous computer training or experience. Employers look to hire employees with good general office skills or courses in business education. Workers in these positions generally receive on-the-job training in the use of any computerized office equipment. Brief training is usually provided by a supervisor or co-worker in the use of a word processor or computer software program. When new equipment is introduced into the workplace, brief training is provided by the manufacturer, in-house trainer, or through self-study. Proficiency is attained within a short time through experience.

Aircraft Mechanics

Aircraft mechanics include avionics technicians, who maintain and repair the computer and electronic equipment on the aircraft, and airframe and powerplant mechanics. Avionics technicians not only have to know computer maintenance and repair, but also how to use computers for diagnostic checks of electronic components. Computerized "test boxes" are built into the newest aircraft; on older aircraft the technician attaches computerized testing devices to the equipment like any other electrical instrument. Similarly, the airframe and powerplant mechanic uses computers to diagnose engine problems. Use of these computerized instruments requires proper attachment and ability to read and understand the results. Some new model aircraft have computerized equipment that continually monitors performance of many parts of the aircraft and alerts the pilot to malfunctions or gives the mechanic a read-out when the aircraft is on the ground. This reduces the trouble-shooting skill requirements for mechanics.

Avionics technicians usually acquire their skill in 2-year or 4-year college or technical institute courses, or in the Armed Forces; some do it by self-study. After being hired they are trained by the employer. They may also be sent to training programs maintained by airframe or avionics equipment manufacturers for periods of from one week up to 11 weeks, depending on what they need to learn about the computer and other electronic equipment on the aircraft. They are given refresher training from time to time, and updating training when new or modified equipment is installed.

Airframe and powerplant mechanics need computer training only to be able to use diagnostic equipment on engines. They receive training from airframe manufacturers or airline training departments. They will need computer training for the newer digital electronic engine control system, for example.

Central Office and PBX Technicians

The most advanced central telephone offices have computer-controlled switching equipment, the equipment that enables a caller to connect with the telephone he or she wants to reach, by dialling a number. It also records the call for billing purposes. Malfunctions anywhere in the system are spotted by an alarm capability built into the system. The technician then diagnoses where the problem is by making some simple checks through the computer terminal, and the malfunctioning part is replaced. Technicians sometimes modify the computer program that does the diagnoses; this is a limited programming skill. More difficult problems are referred to more experienced technicians, and major repairs are done by employees of the equipment manufacturers. The workers doing the more routine maintenance using computers to diagnose and locate problems are called maintenance administrators in some companies.

Both the work done and the training differ among telephone companies. New workers with technical training in electronics or computers from a two-year postsecondary school, or in the military service are given preference in hiring by some companies. Companies formerly in the Bell System give an examination to test employees' technical knowledge, and determine work assignments and the training needed by each individual. Training is provided by the employers and is done in classrooms or through self-study, combined with learning on the job. One company gives a total of 10 to 19 weeks training over a two-year period; those working on the most sophisticated equipment need only the 10 weeks of training. Some workers are sent outside for training provided by equipment manufacturers; one company counts on two weeks of such training, plus on-the-job experience. There is no fixed training period; the training system is flexible to accommodate different levels of technical education before hiring, different work assignments, and changing technology. After a year or two of training and experience a technician is able to handle most maintenance problems that arise in a central office. Rapidly changing technology in this industry necessitates training throughout a worker's career.

Chemical Plant Operators

Continuous process chemical plants are controlled by computerized equipment that monitors the process, recording the heat, pressure, flow rates, levels of liquid, and mix of raw materials, and automatically adjusts each when necessary. The operators watch the monitoring equipment, occasionally adjust some of the controls, and stand ready to take steps to avoid breakdowns or upsets in the process. The programs are written by programmers; the operators do not write programs.

Training depends on the previous experience of the operator and on the particular chemical process involved. One chemical company reported giving a few days to two weeks of classroom training to experienced plant workers, followed by one or two weeks of hands-on experience under the eye of a qualified operator; another gives 280 hours of formal instruction over a 14-month period, (including chemistry, physics and mathematics applicable to the process), in which 30 percent of the time (or about 80-90 hours) is spent on computer application and instrumentation. The latter training program, given to all chemical operators in the company, is followed by specific instruction applicable to the particular chemical process the operator will be monitoring. All the training is paid for by the employers and is given on company time.

Electric Generating Plant Operators

Plant operators monitor the operations of the generating plant, using a computer-controlled panel to keep an eye on fuel consumption, temperature, pressure, power generated, and other aspects of the system. If they see problems building up that will not be averted automatically by the computer, they intervene and make necessary adjustments or stop the operation of a generator until the problem can be corrected.

Utilities hire workers with a high school education as trainees for this job; some additional training in electrical or mechanical technology is helpful. Training is given on the job over a period of as much as five years, during which the worker learns various aspects of generating plant work, including the operation of the computer-controlled monitoring system. Some companies use computer-controlled equipment simulating the control panel of a power plant as a training device. Some operators are sent to brief training programs provided by manufacturers of the computer equipment.

Graphic Arts Occupations

The graphic arts industry has been profoundly affected by the introduction of computer and other electronics technology, yet very little special computer-oriented training is required or given. This is because the most modern equipment has computer controls and/or electronic sensing built in, but there is no special programming to be done by employees of the industry - the computers are all pre-programmed, and the worker in the industry uses the equipment with a general understanding of the principles of computers, but without the need to program the computer. The training is still extensive, but it is concentrated on the substantive graphic arts processes, which are complex and require long periods of training and experience.

Use of computers varies, depending on the printing process used and the size of the plant or the individual printing job. The text to be printed may be typed on computers with word processing programs, and the type for large jobs may be set up by phototypesetting machines. Type and illustrations for newspapers, magazines, catalogues, etc. may be combined on pagination equipment (computer-controlled) on which the layout of each page is done. Illustrations in color are made by first using color-separation scanners that employ filters to separate the color into primary colors and then the intensity of each at each point on the illustration is measured and converted into digitized information. The skilled operator can change the intensity of each color in any part of the illustration and thus modify the color ultimately printed. Lithographic press plates are made by highly automated machines.

In a large press room a press console is operated by the senior pressman; built-in monitors control the amount of ink on the plate. The roll feeder also has a small computer unit to monitor and count the feeding of paper into the press, and the paper cutter and folding machine operators have computer and electronic controls to count the sheets and to inform the operators where jams are occurring in the machines.

Training is adapted to the particular occupation and printing process, as well as to the needs of the worker and the shop in which he or she is employed. It may vary from a six-week program to a four-year apprenticeship, which may be shortened if the worker has previous experience or schooling or learns rapidly. The computer knowledge required is a small part of the total that is imparted and consists of instruction in use of the equipment and a general understanding of the principles of the computer. The worker learns operation of the equipment on the job.

Pattern Graders and Layout Workers, Apparel and Shoe Industry

Computer-controlled systems are in use for pattern grading and marker making for the apparel and shoe industry. The pattern for each part of a garment (front, back, sleeve, collar, etc.) is traced and the shape entered into the computer by a grader, who also locates notches to be cut into each piece to guide the sewer. The pattern for each part is then reproduced in the full range of sizes by the computer, following rules that had previously been entered into the computer's memory.

The marker maker then arranges the patterns on the computer screen on a rectangle representing the fabric spread out on a cutting table, trying to fit them as closely together as possible so that there will be a minimum of waste when the cloth is cut. The computer can be programmed to prevent the marker maker from turning a piece so that a stripe or grain in the fabric is running the wrong way. It also calculates the percentage of the fabric that is wasted by the arrangement, signaling to the marker maker whether a satisfactory job has been done. The computer then draws the marker on a large sheet of paper to be laid over the fabric to guide the cutters; or the computer can itself guide a cutting machine.

The skills and experience of the grader or marker maker are still required. In addition, a new occupation may be created: system manager, whose responsibility it is to organize the work, set up and store on computer disks libraries of rules such as those for size grading, or marker characteristics, and supervise and train the graders and marker makers. Training on the computerized equipment is typically given by the manufacturer of the equipment to the person in the apparel or shoe plant who will manage the system. A typical training period is two weeks; no prior computer experience is needed. It takes up to several months for the system manager to attain proficiency. The system manager or the equipment manufacturer can train experienced marker makers and graders to use the equipment in anywhere from one day to a week or two, depending on the equipment.

Petroleum Refinery Operators

The computerized process control equipment in petroleum refineries tells the plant operator the status of the process, including temperature, pressure, flow of fluids and gases, and fuel consumption. The operator uses this information to control the process. In older refineries, the instruments, and in new refineries the instruments and control devices are electronically operated. In some cases a supervisory computer is used to control the process automatically, following limits pre-set by the operator or the computer program.

Training is done on the job. In some cases a computerized simulator training system is used, in which the computer is programmed to simulate various operating problems and conditions, including various "upsets" or unusual situations that can occur; the operator learns to react to any situation properly (National Petroleum Refiners Association, 1982). Skill in use of the computerized control system amounts to only a part of the total training required.

Systems Operators or Dispatchers, Electric Utilities

These workers control the distribution of electric power over the system, the flow from the various generating plants through the transmission lines to consumers. They also control interchange transactions with other electric power companies, buying power to meet peak loads or to make up for generator outages or transmission line breakdowns, or selling power as needed by the other companies.

They monitor the operation of the system, using a computer to keep track of loads on all lines, output of generating stations, equipment or transmission line outages. They may call other companies by telephone to arrange for power interchanges and prices. They may enter information into the computer. Generally, they do not program the computer themselves, but they may review new computer programs developed by company programmers and suggest improvements.

Persons with some technical education, such as at least an associate degree in engineering technology, are hired for these jobs. They are trained on the job by a combination of classroom training and supervision. Training methods and periods differ among electric utility companies. One may have a two-year training program with as much as 16 hours a week in a classroom or with rotation among related jobs in the company. Another may provide only a few weeks of formal instruction, sometimes including training by manufacturers of the computer controlled equipment, but a period of several years of informal training on the job.

Farm Operators and Managers

Computers are being applied in farm management in many ways, illustrated in the following examples. Accounts of the farm business can be kept and financial analyses made through spread sheets. The yield of milk from cows can be analyzed in terms of both the quantity and the mix of feeds each cow needs, and a special formula can be developed for each cow or a group of cows. Supplies can be ordered through computer networks. Decisions on risk management - what crops to grow, the amounts of fertilizer and insecticides to apply, investment in equipment, and borrowing of money - can be made on the basis of yield and price expectations for crops and cost of materials purchased, soil condition, weather, interest rates, and other variables. Farmers can take computer-assisted courses in various agricultural subjects. Current prices of farm products are available on computerized data bases accessible through modems.

Large and mid-sized farms are more likely to use computers than small farms; about 700,000 farms, or 28 percent of the total, were in the larger size categories in 1981. According to one estimate, about eight percent of farmers owned microcomputers or small home models that they used for farm business in early 1985, and another two or three percent had access to computers (Holt, 1985). Other estimates of computer users range from 5 to 15 percent of full-time farmers. Large dairy farms were active users.

A considerable amount of software designed for farm use is available; an inventory of agricultural software lists over 1,700 programs (Strain and Simmons, 1984). Several states have centralized computer data bases on agricultural subjects, accessible to farmers through computer networks. Farmers rarely have to write their own computer programs.

Farmers learn to use computers through brief (one or two day) seminars provided by vendors of equipment or software, agriculture extension service seminars, courses taken at colleges or community colleges, or by studying the manuals that come with equipment or software, or publications of the agriculture extension services.

STATISTICAL APPENDIX

This appendix describes and compares various bodies of statistics on employment in computer-using occupations and on the number of computers sold or in use. The statistical tables are at the end of the Appendix.

Employment

Statistics on employment by occupation in the United States are derived from three types of sources: surveys of people in households in which the individual or a member of the household reports on the occupations of each person employed, such as the census of population or the Current Population Survey (CPS); surveys of employers in which the employer reports the number of persons employed in each occupation, such as the Occupational Employment Survey (OES) of the Bureau of Labor Statistics; and data compiled by licensing agencies or professional organizations about the number of persons licensed in an occupation or members of a society. In the field of computer-related occupations, only the first two are of practical importance.

The occupational employment data in population censuses and the CPS are collected by interviews in samples of households. The sample used in the 1980 Census of Population to collect economic characteristics was a little over one-sixth of the households; that used in the CPS is about 60,000 households, or less than 0.1 percent of all households. The questionnaire asks what kind of work the individual was doing and also gets other information that helps in properly identifying the occupations reported, such as industry, earnings, and education attained. The occupations reported are coded by Census Bureau occupational coding clerks into the 200 or so categories published in the CPS. The statistics based on the CPS sample have both sampling errors and errors resulting from inaccuracy of reporting and of coding occupations. Annual averages have a sampling error about one-third less than that of the monthly figures (See Table A-4). Reporting and coding errors are more difficult to measure; people frequently overstate their occupational status, and this cannot always be corrected by coding clerks on the basis of the supplementary information collected.

The OES covers a sample of establishments in nonfarm industries. The industries are divided into three groups through which the survey cycles, so that each industry is surveyed once every three years. Different questionnaires are used for each industry, with lists and brief definitions of occupations appropriate to each one. The fact that each worker's occupation is identified by the employer usually makes for more accurate reporting than in surveys based on self-identification; moreover, prelisting of occupations in the questionnaire eliminates coding errors. The survey excludes a few groups of workers: self-employed, farm workers, and employees of a few industries, such as railroads, for which other government agencies collect occupational employment data. To fill in the gaps the BLS gets the missing data from other sources such as the CPS and the other agencies that collect occupational employment data, and it converts estimates collected over the three-year cycle to a single year by assuming that employment in each occupation changes proportionately to changes in total employment in its industry as shown by BLS industry employment statistics collected in a separate survey. The resulting estimates are probably the most accurate occupational employment estimates available. The most recent set of estimates published was for 1982 (Bureau of Labor Statistics, 1984, Table B-1). Table A-1 is drawn from that publication. The total in the table, 101,510,000 exceeds the average employment reported for 1982 by the Current Population Survey, 99,526,000, largely because it is derived from payroll survey data, which counts individuals more than once if they hold more than one job simultaneously.

The differences that arise between CPS-based and OES-based estimates of employment in an occupation are illustrated in Table A-3: the first column shows OES-based data from the source just cited, and the second CPS data for the same year. The very large difference for computer operators is particularly noteworthy. The number of microcomputers (or personal computers) has grown very rapidly in recent years, and they are used widely by people in many occupations; it is possible that some workers who are reported by their employers in other occupations such as bookkeeping clerks may upgrade their status by reporting themselves to CPS as computer operators.

It is likely that the year-to-year changes shown by the CPS are more accurate than the level of employment shown. The CPS data for five computer-related occupations for each year since 1974 are shown in Table A-2. The year-to-year changes are affected by sampling error as shown in Table A-4. They also are not comparable over the years because a new occupational classification system conforming more closely to the Standard Occupational Classification promulgated in 1980 for use by federal agencies was introduced in the CPS beginning in January 1983. The most significant classification changes affected computer systems analysts, which gained in employment by about 20 percent as a result of the inclusion of computer scientists and some workers formerly classified as computer programmers; and computer equipment operators, to which peripheral equipment operators were added in 1983. (This information was based on an analysis of classification changes not yet published, provided by the Bureau of the Census.)

In addition, the 1982 figures for keypunch operators were affected by a decision in that year to count persons reported as "word processors" as keypunch operators. This decision was later rescinded, but as a result the 1982 figures show a large increase—in an occupation that was not increasing with the rest of the computer-related occupations.

Training Received by Workers in Computer-Related Occupations

In January 1983 questions were added to the Current Population Survey on the training workers had received. The first major question was "Did you need specific skills or training to obtain your current job?"; the second major question was "Since you obtained your present job, did you take any training to improve your skills?" In each case, people who responded "yes" were asked to identify the source or sources of the training; many workers mentioned more than one source. The results were tabulated by occupation and analyzed in a recent article (Carey and Eck, 1984).

The results for five computer-related occupations are shown in Table A-8. The first line shows the estimated number of workers in the occupation who needed specific skills or training to obtain their present jobs, and the second line shows what percent this was of all workers employed in the occupation. The remaining lines show, for each source of training, the percent of all workers

employed in the occupation who had received training from that source.

Similarly, in the lower bank of figures in Table A-8, the first line shows the number of workers who had taken training to improve their skills since they obtained their present jobs, the second line shows what percent this was of all workers employed in the occupation, and the subsequent lines show what percent of all workers employed in the occupation had received skill improvement training from each source.

Computers Sold or In Use

Data on units sold are compiled by the Computer and Business Equipment Manufacturers Association (CBEMA), the Electronics Industries Association (EIA), and the Bureau of the Census.

CBEMA data are compiled from reports by members of the association. They are said to be complete, and to reflect domestic consumption (domestically-produced units, less exports, plus imports). The units are classified by size, based on retail price, as follows:

Micro (personal computers)	\$ 1,000-\$ 20,000
Mini	\$ 20,000-\$250,000
Mainframe	\$250,000 and over

One result of the constant-price based definitions is that, at a time when prices have been going down, the growth rate of the smaller sizes may be exaggerated, since some computers that once were in larger size classifications may have shifted into a lower price range. While some of the computers in the smallest size class are purchased for home use, the great bulk of them are used for business or professional purposes. Data for recent years are shown in Table A-5.

EIA compiles sales figures from members of its Consumer Electronics Group Marketing Services Committee, other companies in the industry, and outside research firms. Data on "home computers" represent factory sales, including imports, excluding exports. They are defined as computers retailing at less than \$2,500 and intended for use in homes. While on the face of it there would appear to be an overlap between these and the micro-computer size class in the CBEMA statistics, most of the computers reported on by EIA retail for less than \$1,000, the lower cut-off for CBEMA's micro-computer size class. (Note the average factory value shown in Table A-6.) EIA estimates that there were home computers in 13 percent of all households in January 1985 (Electronic Industries Association, 1985, p. 12). This implies that there were about 11 million home computers.

Bureau of the Census data on manufacturers' shipments of computers and computer equipment are derived from an annual survey on Form MA35R covering the manufacture of computers and office and accounting machines. Data on exports are shown in the published reports, but no data are given on imports of computers. In the report for each annual survey, comparable data for the previous year are shown, based on the reports from the same companies, but the Bureau of the Census has not linked these reports into a series for more than two consecutive years. Data for 1982 and 1983 are shown in Table A-7, where they are used to give clues as to the ratio of the number of computer terminals produced to the number of large computers produced (i.e., those not classified as compact). It was not possible to get a comparable ratio for earlier years because the average reported value per non-compact computer changed radically from the 1982-81 paired comparison to that for 1983-82, and the number of companies included in the comparison doubled, probably indicating a discontinuity of definition or of the type of product being manufactured.

Numerically-Controlled Machine Tools

In 1983 there were about 105,000 numerically-controlled machine tools in the United States, according to the 13th Annual American Machinist Inventory (American Machinist, November 1983). Diffusion of this technology into industry was slow in the 1950's and 1960's, but accelerated somewhat over the past 10 years. These tools amounted to 4.7 percent of all machine tools in American factories in 1983, but probably did a greater percentage of the work done, since newer tools are used more. Some experts have estimated that as many as half the parts made in machine shops are made with NC equipment. They are concentrated in large firms, except in the aerospace and defense industries (Office of Technology Assessment, 1984, p. 59).

Industrial Robots

A report by Tech Tran Corp., Industrial Robots: A Summary and Forecast, 1983, shows that 1,400 units were sold in 1981 and 1,700 in 1982. The Robot Institute of America's Worldwide Robotics Survey and Directory, 1983, shows 6,301 operating robot installations in the United States at the end of 1982, 13 percent of the world supply (Japan had 31,900 at that time) (Office of Technology Assessment, 1984, p. 52). The Robotic Industries Association estimates that 15,000 industrial robots were in use in U.S. industry in March 1985. The automobile manufacturing industry had 35 percent of them (Robotic Industries Association, March 7, 1985).

Table A-1
Civilian Employment In Occupations In Which Computers Are Used, 1982

OCCUPATION	EMPLOYMENT, 1982 (000)
Professional, technical and related workers	
Engineers	1,204.3
Aero-astronautic engineers	43.8
Chemical engineers	56.0
Civil engineers	155.4
Electrical engineers	319.5
Industrial engineers	160.2
Mechanical engineers	209.1
Metallurgical engineers	14.0
Mining engineers	5.7
Nuclear engineers	6.3
Petroleum engineers	26.1
All other engineers	208.1
Life and physical scientists	271.0
Agricultural scientists	21.7
Biological scientists	51.6
Chemists	88.8
Geologists	48.6
Medical scientists	7.2
Physicists	18.8
All other life and physical scientists	34.2
Mathematical specialists	47.9
Actuaries	8.2
Mathematicians	10.6
Statisticians	20.1
All other mathematical specialists	9.1
Engineering and science technicians	1,243.3
Broadcast technicians	17.1
Civil engineering technicians	35.2
Drafters	302.4
Electrical and electronic technicians	366.2
Estimators and drafters, utilities	6.0
Industrial engineering technicians	27.4
Mechanical engineering technicians	47.8
Surveyors	43.6
All other engineering and science technicians	397.6
Medical workers, except technicians	
Dietitians	44.3
Nurses, registered	1,312.4
Pharmacists	151.0
Physicians	479.1

Health technicians and technologists	
Biochemistry technologists	11.6
Blood bank technology specialists	17.0
Cytotechnologists	4.7
Histologic technologists	6.6
Medical laboratory technicians	57.4
Medical laboratory technologists	102.8
Microbiology technologists	8.8
EEG technologists	5.5
EKG technicians	20.9
Emergency medical technicians	5.5
Health record technicians	21.6
Pharmacy helpers	33.0
Physician and medical assistants	122.9
Radiologic technologists	110.0
Radiologic technologists and nuclear medical technicians	36.2
X-ray technicians	73.8
Surgical technicians	34.8
All other health technologists and technicians	82.4
Airplane pilots	79.7
Air traffic controllers	20.9
Library technicians	29.1
Tool programmers, numerical control	12.3
Computer specialists	520.8
Computer programmers	266.4
Computer systems analysts	254.4
Social scientists	205.6
Economists	30.0
Financial analysts	19.3
Psychologists	82.5
Sociologists	5.7
Urban and regional planners	21.4
All other social scientists	46.7
Teachers	3,656.7
Adult education teachers	124.7
College and university faculty	744.0
Extension service specialists	13.5
Graduate assistants	139.8
Kindergarten and elementary school teachers	1,366.1
Secondary school teachers	1,024.1
Vocational education teachers	97.9
All other teachers (except dance and athletic coaches)	146.6
Commercial and graphic artists and designers	132.8
Designers	179.7
Reporters and correspondents	51.1
Writers and editors	119.7
Other professional and technical workers	
Accountants and auditors	855.8
Architects	84.2
Claim examiners, property/casualty insurance	22.4
Cost estimators	92.4
Foresters and conservationists	30.9
Law clerks	40.5

Lawyers	464.5
Legal assistants	45.3
Librarians	150.6
Purchasing agents and/or buyers	176.7
Underwriters	75.8
Managers, officials and proprietors	
Sales managers, retail trade	271.5
School administrators	132.8
Store managers	970.5
Wholesalers	247.4
Sales workers	
Real estate agents and brokers	337.3
Security salesworkers	78.3
Travel agents	61.9
Clerical workers	
Bank tellers	538.8
Bookkeepers and accounting clerks	1,713.0
Cashiers	1,570.2
Checking clerks	18.6
Circulation clerks	9.5
Claims adjusters	66.0
Claims clerks	66.4
Claims examiners, insurance	47.3
Clerical supervisors	466.7
Court clerks	27.3
Credit clerks, banking and insurance	49.6
Customer service representatives	88.9
Dispatchers, police, fire, and ambulance	47.8
Dispatchers, vehicle service or work	90.3
File clerks	294.7
General clerks, office	2,348.4
In-file operators	5.0
Insurance checkers	15.0
Insurance clerks, except medical	10.6
Insurance clerks, medical	85.7
Library assistants	81.1
Postal service clerks	306.5
Office machine operators	
Bookkeeping and billing operators	227.0
Computer operating personnel	579.9
Computer operators	210.9
Data entry operators	320.0
Peripheral EDP equipment operators	49.0
Order clerks	265.2
Reservation agents and transportation ticket clerks	102.2
Reservation agents	52.9
Ticket agents	49.3
Secretaries	2,441.5
Stenographers	269.6
Typists	990.0
Service clerks	23.6
Shipping and receiving clerks	364.8
Sorting clerks, banking	7.4
Stock clerks, stockroom and warehouse	830.9

Directory assistance operators	37.5
Transportation agents	20.6
Craft and related workers	
Aircraft mechanics	108.0
Communications equipment mechanics	91.8
Computer service technicians	54.6
Printing trades craft workers	
Typesetters and compositors	104.4
Lithographers and photoengravers	67.3
Printing press operators	173.8
Control room operators, steam	7.9
Power station operators	16.3
Farmers and farm managers	1,447.7
TOTAL	30,725.4
Total employment, all occupations	101,510.1

Source: Employment data from: Bureau of Labor Statistics, Occupational Projections and Training Data, 1984 Edition, Bulletin 2206, May, 1984, Table B-1, pp. 80-90.

Table A-2
Employment In Computer-Related Occupations, Annual Averages, 1974-1984
(From CPS)

(000)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Computer programmers	203	228	235	228	255	330	351	367	434	443	507
Computer systems analysts[a]	99	124	139	132	155	181	205	213	242	276	310
Computer equipment operators[b]	251	302	295	311	403	465	535	564	588	605	718
Keypunch operators[c]	251	253	279	284	277	279	271	248	364	311	351
Data processing machine repairers	51	59	52	52	65	94	86	100	84	98	107

a/ Beginning in 1983 this category is called "computer systems analysts and scientists".

b/ Includes peripheral equipment operators beginning in 1983.

c/ Beginning in 1983, title changed to "data entry keyers".

Source: 1974-1981: Bureau of Labor Statistics, Labor Force Statistics Derived from the Current Population Survey: A Databook, Bulletin 2096, September 1982, Vol. 1, Table B-20, pp. 651-667. 1982-1984: Bureau of Labor Statistics, Employment and Earnings, January issues, 1983, 1984, and 1985.

Table A-3
Comparison of Estimates of Employment In Computer-Related Occupations in 1982 From OES and CPS

Occupation	Employment, 1982 (000)	
	OES	CPS
Computer programmers	266	434
Computer systems analysts	254	242
Computer operators	260	588
Keypunch operators	320	364
Data processing machine repairers	55	84
TOTAL	1,155	1,712

Source: 1982 OES: Bureau of Labor Statistics, Occupational Projections and Training Data, 1984 Edition, Bulletin 2206, May 1984, Table B-1, pp. 80-91. 1982 CPS: Bureau of Labor Statistics, Employment and Earnings, January 1983.

Table A-4
Standard Errors of Estimates in The Current Population Survey

Level of estimate	Standard error of estimates of the level each month	Standard errors of annual averages	
		Level of estimate	Year-to-year change
50,000	10,000	6,700	7,000
100,000	14,000	9,400	9,800
500,000	32,000	21,400	22,400

The chances are two out of three that if a complete census were taken the result would differ from the sample survey results by less than the standard error; the chances are 19 out of 20 that results of a census would differ from sample survey results by less than twice the standard error.

Table A-5
Annual Domestic Consumption of Computers, 1980-1984, and Cumulated Number at Year End, by Size Class

---

(000)

	Domestic Consumption a/				Cumulated, end of year b/			
YEAR	Total	Micro	Mini	Mainframe	Total	Micro	Mini	Mainframe
1979	--	--	--	--	2,550	2,169	272	109
1980	302	251	41	10	2,852	2,420	313	119
1981	440	385	44	11	3,292	2,805	357	129
1982	793	735	48	11	4,085	3,540	405	140
1983	1,315	1,260	45	10	5,300	4,800	450	150
1984	2,182	2,100	72	10	7,582	6,900	522	160

a/ Domestic production, less exports, plus imports.

b/ Some computers produced in earlier years are no longer in active use.

Source: Computer and Business Equipment Manufacturers Association (Figures may not add to totals because of rounding).

Table A-6
Home Computers: Sales to Dealers, 1982-1984

Year	Number of Units (000)	Average Value ($ per unit)
1982	2,000	$650
1983	4,800	406
1984	5,100	440

Source: Electronic Industries Association: Consumer Electronics Group, Consumer Electronics: U.S. Sales by Product Category, January 1985. "Data were developed from input of the EIA-CEG Marketing Services Committee members, other companies in the industry, and outside research firms. They are not derived from regular EIA Marketing Services Department reporting programs." Data include factory sales of home computers, excluding exports and including imports. Home computers retail at less than $2,000 and are intended for use in homes. The value shown in the table is factory value.

Table A-7
Selected Data on Computer Production from the
Bureau of Census, 1982 and 1983

	1982			1983		
	Quantity (000)	Value ($ million)	Avg. value per unit ($ 000)	Quantity (000)	Value ($ million)	Avg. value per unit ($ 000)
Complete computers	2,099	11,356	5.4	4,214	13,268	3.1
General purpose						
Digital						
Compact	1,946	4,375	2.2	3,948	6,095	1.5
Other	118	6,108	51.8	229	6,326	27.6
Analog and hybrid	2	87	35.1	5	115	21.2
Special purpose						
Digital	30	637	21.4	29	569	19.7
Analog and hybrid	2	149	62.7	2	162	65.1
Computer terminals	1,795	-----	----	1,833	----	----
Automatic typing and word processing machines	187	1,479	7.9	230	1,566	6.8
Ratio, Terminals per computer (excl. compact digital computers)	11.8	-----	----	6.9	-----	----

Source: Bureau of the Census, Current Industrial Reports: Computers and Office and Accounting Machines, 1983) MA35R (83-1), Issued October 1984, Table 2. Data are manufacturers' shipments, whether for domestic or export sale or lease. Value is net sales price f.o.b. plant. Average value per unit was calculated from unrounded data.

Table A-8

How Workers in Computer-Related Occupations Were Trained

	Computer Systems Analysts and Scientists	Computer Programmers	Data Processing Equipment Repairers	Computer Operators	Data Entry Keyers
WORKERS NEEDING TRAINING TO QUALIFY FOR CURRENT JOB					
Number (000)	395	371	89	408	213
Percent of employment in occupation a/	90	91	92	75	71
Sources of training (percent of occupational employment):					
Any school b/	66	64	57	35	31
Vocational education:					
High school	4	1	8	11	12
Post high school					
Private	3	4	3	4	4
Public	1	4	12	2	6
Junior college or technical institute	9	19	25	15	9
College, 4 years or more	51	40	8	7	2
Employer training					
Formal c/	26	19	31	15	14
Informal OJT d/	41	41	30	44	41
Armed Forces	5	3	22	2	1
Correspondence courses	1	1	3		
Friends and others e/	1	1	1	1	1
WORKERS WHO TRAINED TO IMPROVE THEIR SKILLS					
Number (000)	284	249	65	247	79
Percent of employment in occupation a/	65	61	67	46	27
Sources of training (percent of occupational employment):					
School	21	25	10	13	5
Company:					
Formal c/	36	27	58	17	8
Informal OJT	24	24	10	26	14
Other	7	5	10	2	1

Source: Carey and Eck, 1984.

a/ Percent is less than the sum of specific sources of training because many workers reported more than one source of training.

b/ Percent is less than the sum of specific types of school because some workers reported more than one source of schooling.

c/ Includes apprenticeship or other type of training having an instructor and a planned program.

d/ Includes experience in previously held jobs.

e/ Informal training from a friend or relative or other experience not related to work.

REFERENCES

Abernathy, Sandra M., and Pettibone, Timothy J. "Computer Literacy and Certification: What States Are Doing." *Technical Horizons in Education Journal*, Vol. 12, No. 4 (November 1984): 117-119.

Abrams, Lawrence, and Grieb, Dorothy. *Health Careers Guidance Manual for the Greater Philadelphia Region*. Philadelphia: College of Allied Health Sciences, Thomas Jefferson University, 1982.

Accreditation Board for Engineering and Technology, Inc. *Criteria for Accrediting Programs in Engineering in the United States*. New York: Accreditation Board for Engineering and Technology, Inc., 1984.

Accreditation Board for Engineering and Technology, Inc. *Criteria for Accrediting Programs in Engineering Technology*. New York: Accreditation Board for Engineering and Technology, Inc., 1984.

American Chemical Society, Committee on Professional Training. *Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures.* Washington, D.C.: American Chemical Society, 1983.

American Institute of Banking in New York. *School of Banking 1984-1985*. New York: Author, 1984.

American Institute of Design and Drafting, CADD Committee. *Report on Survey Made in 1983*. Rockville, Md: American Institute for Design and Drafting, 1984.

American Medical Association, American Medical Record Association. *Essentials and Guidelines of an Accredited Education Program for the Medical Record Administrator*. Chicago: Author, 1981.

American Medical Association, American Medical Record Association. *Essentials and Guidelines of an Accredited Educational Program for the Medical Record Technician*. Chicago: Author, 1983.

Anderson, Richard E., and Kasl, Elizabeth Swain. *The Costs of Financing Adult Education and Training*. Lexington, Mass.: Lexington Books, 1982.

Anderson, Ronald. *Survey of Computer Literacy*. Minneapolis, Minn.: Instructional Computing, Inc., 1982.

Austin, William M., and Drake, Lawrence C., Jr. "Office Automation and Employment." *Occupational Outlook Quarterly*, Spring Issue, 1985.

Ayers, Robert, and Miller, Steven. *The Impacts of Industrial Robots*. Report No. CMU-RI-TR 81-7. Pittsburgh: The Robotics Institute, Department of Engineering and Public Policy, Carnegie-Mellon University, 1981.

Becker, Gary S. *Human Capital. A Theoretical and Empirical Analysis, with Special Reference to Education*. Princeton, N.J.: Princeton University Press, 1964.

Boss, Richard. "Technology and the Modern Library." Library Journal, June 15, 1984: 1183-1189.

Buchholz, Barbara B. "Supermarket Computers: More To Come." St. Louis (MO) Post-Dispatch, November 19, 1984: F11-F12.

Bureau of Labor Statistics, Department of Labor. Occupational Projections and Training Data: 1984 Edition. Bulletin 2206. Washington, D.C.: U.S. Government Printing Office, 1984.

Carey, Max, and Eck, Alan. "How Workers Get Their Training." Occupational Outlook Quarterly, Vol. 28, No. 4 (Winter 1984): 2-21.

Carruthers, Robert and Associates. Computer Literacy: An Introduction. Albany, N.Y.: Center for Learning Technologies, State Education Department, 1983.

Christen, Kate, and Gladstone, Peggy. "EL's Third Annual Survey of the States." Electronic Learning, Vol. 3, No. 3 (Nov./Dec. 1983): 37-54.

The College Board. Academic Preparation for College: What Students Need to Know and Be Able to Do. New York: The College Board, 1983.

"Computers and Medical Education." Pulse, August 1984: A.

Conference Board of the Mathematical Sciences, Committee on School Education. Recommendations Regarding Computers in High School Education. Washington, D.C.: Conference Board of the Mathematical Sciences, 1972.

Conference Board of the Mathematical Sciences. The Mathematical Sciences Curriculum K-12: What Is Still Fundamental and What Is Not. Report to the NSB [National Science Board], Commission on Precollege Education in Mathematics, Science and Technology. Washington, D.C.: The Conference Board of the Mathematical Sciences, 1982.

Crohn, Leslie. Technological Literacy in the Workplace. Portland, OR: Northwest Regional Educational Laboratory, September 1983.

Dale, Charles. "Employment Effects of the Defense Budget: A Descriptive Survey" in Responsiveness of Training Institutions to Changing Labor Market Demands, Robert E. Taylor, Howard Rosen, and Frank C. Pratzner, eds. Columbus, OH: The National Center for Research in Vocational Education, 1983.

Eden, Harry S., and Eden, Murray. Microcomputers in Patient Care. Park Ridge, NJ: Noyes Medical Publications, 1981.

Education TURNKEY Systems, Inc. Uses of Computers in Education. Washington, D.C.: National Commission for Employment Policy, 1985.

Electronic Industries Association. Consumer Electronics: U.S. Sales by Product Category. Washington, D.C.: Electronic Industries Associates, January 1985.

Fosdick, Howard. "Trends in Information Science Education." Special Libraries, Vol. 75, No. 4, October 1984:292-302.

Freedman, Marcia. Training for Telecommunications Occupations. New York: Polytechnic Institute of New York, 1984.

Fusselman, Kay. "Secretaries Wanted." The Secretary, January 1985: 3-20.

Gable, Fred B. Opportunities in Pharmacy Careers. Skokie, IL: VGM Career Horizons, 1982.

Gartaganis, Arthur. "Managers: The Guiding Hands in an Organization." Occupational Outlook Quarterly, Vol. 28, No. 3 (Fall 1984):2-13.

Gerke, Eugene E. "The Microcomputer Revolution Continues." IGA Grocergram, December 1984: 8-10.

Gleaves, Edwin S. "Library Education: Issues for the Eighties." Journal of Education for Librarianship, Vol. 22, No. 4 (Spring 1982):260-274.

Gray, James. "The Computer Revolution Reaches Private Practice." Medical Economics, Oct. 3, 1983: 236-244.

Hansen, John A. Bureau of Labor Statistics Methodology for Occupational Forecasts (Incorporating Technological Change). Boston: Center for Technology and Public Policy, April 1984.

Hewlett-Packard Co. HP Customer Training and Consulting. Hewlett-Packard Co., 1983.

Hollenbeck, Kevin; Pratzner, Frank C.; and Rosen, Howard, eds. Displaced Workers: Implications for Educational and Training Institutions. Columbus, OH: The National Center for Research on Vocational Education, 1984.

Holt, Donald A. "Computers in Production Agriculture." Science, Vol. 228, No. 4698, April 26, 1985: 421-427.

Hunt, H. Allen, and Hunt, Timothy. Human Resource Implications of Robotics. Kalamazoo, Mich.: W.E. Upjohn Institute for Employment Research, 1983.

Hunter, Beverly, and Aiken, Robert. Computer Literacy in Vocational Education: Perspectives and Directions. Knoxville, TN: Office for Research in High Technology Education, The University of Tennessee, December 1984.

Hunter, B.; Kastner, C.; Rubin, M.; and Seidel, R. *Learning Alternatives in U.S. Education: Where Student and Computer Meet*. Englewood Cliffs, N.J.: Educational Technology Publications, 1975.

James, John A. *Perspectives on Technological Change: Historical Studies of Four Major Innovations*. Washington, D.C.: National Commission for Employment Policy, 1984.

Johnson, D.C; Anderson, R.; Hansen, T.; and Klassen, D.L. *Computer Literacy: What Is It?* St. Paul, MN: Minnesota Educational Computing Consortium, 1978.

Kennedy, D.; Craypo, C.; and Lehman, M., eds. *Labor and Technology: Union Responses to Changing Environments*. University Park, PA: Pennsylvania State University, Department of Labor Studies, 1982.

Koerner, James D. *The New Liberal Arts Program: A Status Report*. New York: The Alfred P. Sloan Foundation, 1984.

Kraft, Philip. "The Industrialization of Computer Programming: from Programming to Software Production," in *Case Studies in the Labor Process*, Andrew Zimbalist, ed., New York: Monthly Review Press, 1979, pp. 1-17.

Lancaster, F. Wilfred. *Libraries and Librarians in an Age of Electronics*. Arlington, VA: Information Resources Press, 1982.

Lawyer Hiring & Training Report, Vol. 5, Number 2, July 1984, pp. 1, 16, 17.

Leontief, Wassily, and Duchin, Faye. *The Impacts of Automation on Employment, 1963-2000*. New York: Institute for Economic Analysis, 1983 (mimeo).

Levin, Henry and Rumberger, Russell. *The Education Implications of High Technology*. Palo Alto, CA: Institute for Research on Educational Finance and Governance, Stanford University, 1983.

Lockheed, M.; Hunter, B.; Anderson, R.; Beazley, R.; and Esty, E. *Computer Literacy: Definition and Survey Items for Assessment in School*. Washington: National Center for Education Statistics, 1983.

Nardone, Tom. "Looking at the Future." *Occupational Outlook Quarterly*, Vol. 28, No. 3 (Fall 1984):14-19.

Nardone, Tom. "Numerical-Control Machine-Tool Operators." *Occupational Outlook Quarterly*, Vol. 29, No. 1 (Spring 1985): 10-14.

National Center for Education Statistics. *The Condition of Education 1984 Edition*. Washington, D.C.: Government Printing Office, 1984.

National Center for Education Statistics. *Survey of Participation In Adult Education 1978*. Washington, D.C.: Government Printing Office, 1979.

National Commission for Employment Policy. *8th Annual Report: The Work Revolution*. Report No. 15. Washington: National Commission for Employment Policy, 1982.

National Education Association. Computers in the Classroom. Washington, D.C.: Author, 1983.

National Petroleum Refiners Association. Papers Presented at NPRA Computer Conference, October, 1982 (Especially papers by R.P. Schlenker, A.J. Andrews and P.U. Webb, James H. Miller, William L. Walker, D.A. Dybowski, and Thomas J. Dempsey). Washington, D.C.: National Petroleum Refiners Association, 1982.

"New View of 'Computer Literacy' Emerging." SchoolTechNews, Vol. 2, No. 4 (December 1984):8.

Office Automation Reporting Service. PC Training Issues for Managers & Professionals. Framingham, MA: International Data Corp., June 1984.

Office of Technology Assessment, Congress of the United States. Automation and the Workplace: Selected Labor, Education, and Training Issues. A Technical Memorandum. Washington, D.C.: Office of Technology Assessment, 1983.

Office of Technology Assessment, Congress of the United States. Computerized Manufacturing Automation: Employment, Education and the Workplace. Washington: OTA, April 1984.

Office of Technology Assessment, Congress of the United States. Informational Technology and Its Impact on American Education. Washington: OTA, 1982.

O'Neill, Catherine. "The Drug Dispensers." The Washington Post, March 13, 1985.

O'Neill, Robert E. "Computerized Pharmacies Dispense Consumer Confidence." Progressive Grocer, May 1984: 149-154.

Onore, Allan J. "Using Personal Computers in Tax Practice." American Bar Association Journal, Vol. 70 (January 1984):97-98.

Pogrow, Stanley. Education in the Computer Age: Issues of Policy, Practice and Reform. Beverly Hills, CA: Sage Publications, 1983.

Poirot, James L. Computers and Education. Austin, Tex.: Sterling Swift Publishing Co., 1980.

Richie, Richard W.; Hecker, Daniel E.; and Burgan, John U. "High Technology Today and Tomorrow: A Small Slice of the Employment Pie," Monthly Labor Review, November 1983:50-58.

Robotic Industries Association. Background Report on the U.S. Robotics Industry. Dearborn, Mich.: Robotics Industries Association, March 7, 1985.

Rumberger, Russell W., and Levin, Henry M. *Forecasting the Impact of New Technologies on the Future Job Market*. Palo Alto, CA: Institute for Research on Educational Finance and Governance, Stamford University, February 1984. (Project Report No. 84-A4)

Schreiber, Rita R. "The CAD Operator Today...and Tomorrow." *Manufacturing Engineering*, December 1984, pp. 103-105.

Seidel, R.; Anderson, R.; and Hunter, B. *Computer Literacy: Issues and Directions for 1985*. New York: Academic Press, 1982.

Sherman, Susan W., ed. *Education for Tomorrow's Jobs*. Committee on Vocational Education and Economic Development in Depressed Areas, Commission on Behavioral and Social Sciences and Education, National Research Council. Washington, D.C.: National Academy Press, 1983.

Shulman, Richard E. "Handheld Data Entry Units Increase Computer Capability." *Supermarket Business*, January 1982: 33-34.

Stanton, Michael. "Computer-Aided Design." *Occupational Outlook Quarterly*, Vol. 29, No. 1 (Spring 1985): 2-8.

Stedman, Jim. *Computers in Elementary and Secondary Schools: Federal Role*. July 13, 1984.

Strain, J. Robert and Simmons, Stephanie. *The Cooperative Extensive Service Update Inventory of Computer Programs*. Institute of Food and Agricultural Services, Florida Cooperative Extension Service, Circular 531-A, April 1984.

Sugarman, Carole. "Undercover Cashier." *The Washington Post*, May 30, 1984.

Tidball, Charles S., and Shelesnyak, M.C., eds. *Frontiers in the Teaching of Physiology: Computer Literacy and Simulation*. Bethesda, Md.: American Physiological Society, 1981.

U.S. Bureau of the Census. *Statistical Abstract of the United States: 1984 (104th edition)*. Washington, D.C.: Government Printing Office, 1983.

U.S. Department of Agriculture Graduate School. *Career Planning and Development Programs: Module X, Computer Sciences*. Washington, D.C.: Graduate School, U.S.D.A., 1984.

U.S. Department of Commerce, Office of Assistant Secretary for Trade Development. *A Competitive Assessment of the United States Software Industry*. Washington, D.C., 1984.

Werneke, Diane. *Microelectronics and Working Women: A Literature Summary*. Committee on Women's Employment and Related Issues, Commission on Behavioral and Social Sciences and Education, National Research Council. Washington, D.C.: National Academy Press, 1984.

ABOUT THE AUTHORS

HAROLD GOLDSTEIN, formerly Assistant Commissioner for Manpower and Employment Statistics of the Bureau of Labor Statistics, is the author of: *Training and Education by Industry* and *A Critical Look at the Measuring of Work* (with Willard Wirtz), published by the National Institute for Work and Learning; *Employee Training: Its Changing Role and Analysis of New Data* (with Anthony P. Carnevale), published by The American Society for Training and Development; chapters or articles on "Projections of Demand for Scientists and Engineers" (National Science Foundation), "State and Local Labor Force Statistics" (National Commission on Employment and Unemployment Statistics), "Occupational Forecasts and Vocational Education" (*Vocational Education*), "Changing Structure of Work: Occupational Trends and Implications" (in *Designing Careers*, published by National Vocational Guidance Association); and other articles on manpower, training, and employment.

BRYNA SHORE FRASER, a Senior Program Officer at the National Institute for Work and Learning (NIWL), is the director of the National Study of Fast Food Employment and the author of: *New Office and Business Technologies: The Structure of Education and (Re)Training Opportunities*, prepared for the National Academy of Sciences; *Training Adults for New Office and Business Technologies*, published by The University of Tennessee; *The Structure of Adult Learning, Education, and Training in the United States*, published by NIWL; *Fast Food Jobs* (with Ivan Charner), published by NIWL; *Between Two Worlds: Youth Transition from School to Work* (with Paul Barton), published by NIWL; and other publications on employment and training issues.

☆ U.S. Government Printing Office: 1986—151-703